THE ROLE OF SOILS FOR PTERIDOPHYTE DISTRIBUTION IN TROPICAL AMERICAN FORESTS

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ABSTRACT

The distributions of plant species are affected by characteristics of their environment, most importantly climate and soils. Ferns and lycophytes (hereafter pteridophytes) are no exception to this general ecological principle. However, until relatively recently, little information has been available about pteridophyte-soil relationships in the tropics. Here we review literature that sheds light on the impact of soil conditions on pteridophyte distribution in the lowland forests of tropical America. We provide examples of both soil-related community-level patterns in species turnover and distributions of individual species and genera along soil gradients. We then discuss the relevance of these patterns for the evolution and diversification of pteridophyte lineages and for practical applications, such as the use of pteridophytes as indicators in classification and mapping of soil-related habitats. Finally, we discuss challenges in filling the gaps of knowledge in pteridophyte-soil relationships and suggest possible solutions for them.

INTRODUCTION

Globally, vegetation is classified into biomes according to regionally dominant physiognomy and life-forms. These mostly reflect the prevailing climatic conditions, especially precipitation and temperature, which generally vary gradually over long distances and large extents (e.g., Woodward et al., 2004). In contrast, soil factors can vary sharply over short distances, and are therefore considered important mostly at finer scales. Extreme soil conditions can give rise to azonal vegetation, i.e. to physiognomy that is considered atypical for the climatic zone (e.g., Walter & Breckle, 1986). Although it is in many cases obvious that structural changes in vegetation are related to changes in floristic composition, floristic variation related to soils can take place also within structurally uniform vegetation, which is not obvious at first glance.

Early quantitative attempts to determine fern species occurrences along soil gradients were made by Wherry (Wherry, 1917, 1920), who observed species on different rock types in the Appalachian mountains and carried out chemical analyses to assess fern species occurrences along a gradient of soil calcium concentration and acidity. Petersen (1985) provided a review on what was known of edaphic (i.e. soil-related) niche requirements of ferns at the time, mostly based on studies in North America. More recently, a study in Norway applied rigorous statistical methods to model how the abundances of three fern species varied along several environmental gradients, including soil pH, cation exchange capacity and base saturation (Odland et al., 1995).

In the American tropics, Tryon (1944) observed that the genus *Doryopteris* predominantly occurs in rocky sites above 300 m elevation. He speculated that the centre of origin of the genus was in the southern end of the Brazilian rocky highlands, where the environmental conditions have been relatively stable and available for plants since the Mesozoic. For the subsequent five decades after Tryon's paper, most studies focused on how pteridophyte species distributions relate to geographical regions, elevation, climate or structurally defined vegetation or habitat types (e.g., forest, scrub, cliff), but ignored soil properties (Tryon, 1960; 1972; Smith, 1972; Tryon & Conant, 1975; Parris, 1985; Moran, 1995). Other studies mentioned specific aspects of the soils (e.g., if they were rocky or sandy) when describing the preferred habitats of pteridophyte species, but without including quantitative data on physical or chemical soil properties (Kramer, 1974; Parris, 1976; Cremers, 1991; van der Werff, 1992).

Floristic gradients are especially challenging to observe and document in lowland tropical rain forests, which combine a complex multi-layered vegetation with high species richness and poorly resolved species taxonomy. Detailed information on the soil relationships of any plants in the rain forests of tropical America has started to accumulate only relatively recently. With few exceptions (e.g., Gentry, 1981) researchers in the 1980s paid little attention to local site conditions. The quantitative documenting of soil chemistry in connection with floristic studies started in the 1990s (Duivenvoorden, 1995; Tuomisto et al., 1995; Ruokolainen et al., 1997) but only became routine in the 2000s (e.g., Tuomisto et al., 2003a; 2003b; 2003c; 2016; Ruokolainen et al., 2007; Phillips et al., 2003; Schulman et al., 2004; Baltzer et al., 2005; Fine et al., 2005; Higgins et al., 2011; 2012; Baldeck et al., 2013; 2016).

Quantifying and mapping exact soil characteristics is laborious and expensive, as it requires measurements to be made in laboratories. Nevertheless, there is potential for useful information relevant for species distributions to emerge. The soils in tropical America have various origins and histories (Chauvel et al., 1987; Lips & Duivenvoorden, 1996; Vitousek et al., 2003; Rossetti et al., 2005; Quesada et al., 2011; Quesada & Lloyd, 2016). As a result, soils in some areas are formed by *in situ* weathering of base rock and in other areas by weathering of fluvial or marine sedimentary deposits; differences in texture (the relative contents of sand, silt and clay in a soil sample) and chemical composition (concentration of macro and micronutrients) that are relevant for plants can emerge due to differences in the mineralogical composition of the original parent material and through sorting processes during sedimentation. In addition, climate and the amount of time that has been available for surface erosion and weathering are important, because the weathering process causes leaching of nutrients, which gradually impoverishes the soils.

In addition, plants are affected by hydrological conditions, which vary with climate, topography and soil texture. Some combinations between these three factors can lead to anoxic conditions due to permanent waterlogging or seasonal flooding (Wittmann et al., 2002; Engelbrecht et al., 2007; Parolin, 2009). Overall, climate and edaphic conditions can be considered to be filters for species establishment.

Here we provide an overview of field studies focusing on pteridophyte–soil relationships in lowland forests of tropical America. We address both community-level patterns and the edaphic niches of some pteridophyte species. We also discuss the broader relevance of these relationships for the biogeography and evolutionary history of pteridophytes, and possible applications of the current knowledge

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COMMUNITY-LEVEL PATTERNS ALONG EDAPHIC GRADIENTS

Soil chemistry and texture

Historical overview

Early studies on pteridophyte–soil relationships in the American tropics focused on pteridophyte species lists from sites with contrasting soil types. For example, Cremers (1991) compared fern communities between rocky and clayey substrates in French Guiana. Peruvian Amazonian ferns were compared by Young and León (1989) between clay soil and loamy sand soil and by van der Werff (1992) among inundated sites, swamps and white-sand soils. Tuomisto and Ruokolainen (1994) documented quantitatively how species composition and abundances change in the transition from loamy soils to white sand soils in Peruvian Amazonia. All of these studies found many species restricted to only one of the observed substrates, and concluded that the overall species richness was fostered by environmental heterogeneity and substrate specificity of most pteridophyte species.

To obtain a more general view of compositional variation across moist forests in tropical America, Tuomisto and Poulsen (1996) compiled the locality-specific species lists published until then into a sites by species table. They then carried out community-level ecological analyses on the data set, which contained many localities from Amazonia and some from the Guianas and Central America. In spite of the broad geographical coverage and differences in climate among the sites, ordinations revealed that the most important compositional variation could be associated with a gradient from extremely nutrient-poor white sand soils to nutrient-rich, often clayey soils.

Since then, many studies have made quantitative inventories of pteridophytes and collected surface soil samples for chemical and textural analyses to test the pteridophyte-soil relationships in more detail. These studies have both documented patterns of species turnover and assessed how this turnover is related to different edaphic gradients. Some studies have simplified the soil information to one or a few synthetic variables (e.g. PCA ordination axes), which allows assessing the importance of general soil gradients but does not clarify the relative importance of the different soil properties (e.g., Costa et al., 2005; Jones et al., 2008; 2016).

Exchangeable base cations and aluminium

In those studies that have assessed soil variables separately, the most consistent pattern that has emerged is that pteridophyte species turnover is strongly related to variation in the concentration of exchangeable base cations (Ca, K, Mg, Na). In all the studies, the sum of bases has emerged as one of the most important factors in data analyses. One or more of the individual base cations have invariably been found significant as well. This has been the situation in lowland forests both in Amazonia (figure 1; Tuomisto et al., 1995; 2003a; 2003b; 2003c; 2016; Ruokolainen et al., 2007; Higgins et al., 2011; Zuquim et al., 2012; Moulatlet et al., 2014) and in Central America (Jones et al., 2006, 2013). The importance of base cations conforms with expectation, as all of them except Na are essential plant nutrients that play important roles in physiological processes such as photosynthesis, water uptake and intracellular transportation of solutes (Jackson et al., 2000).

Studies made in Hawaii found that leaf Ca, K and Mg contents varied both within and among species, but no clear relationship with the concentration of the corresponding

elements in the soil was found (Amatangelo & Vitousek, 2008; Richardson & Walker, 2010). The clearest result was a phylogenetic signal: polypod ferns had systematically higher leaf Ca, K and Mg contents than non-polypod ferns. When compared to angiosperms, both polypod and non-polypod ferns had lower leaf Ca contents, but K contents were higher in polypods than angiosperms and Mg contents were similar. It has been hypothesized that fern leaves have low Ca content because ferns evolved in soils with low Ca concentration (Amatangelo & Vitousek, 2008), but whether extant ferns with different soil Ca preferences differ in leaf Ca content is not known. Furthermore, the studies carried out in Hawaii included only 15 pteridophyte and six angiosperm species, and since we do not know similar studies in continental tropical America, it is unclear how general the observed pattern is.

The contribution of other chemical variables to explain pteridophyte species turnover has been more erratic. Aluminium, for example, can be toxic in high concentrations and potentially constrain fern growth by limiting nutrient uptake and root development (Schmitt et al., 2017). Many pteridophytes have developed evolutionary strategies to tolerate aluminium (Olivares et al., 2009), and aluminium accumulation seems to be more common in terrestrial ferns than in angiosperms (Schmitt et al., 2017). Epiphytic species show lower levels of aluminium accumulation than terrestrial species, which is not surprising given that epiphytes do not have a direct connection with the soil.

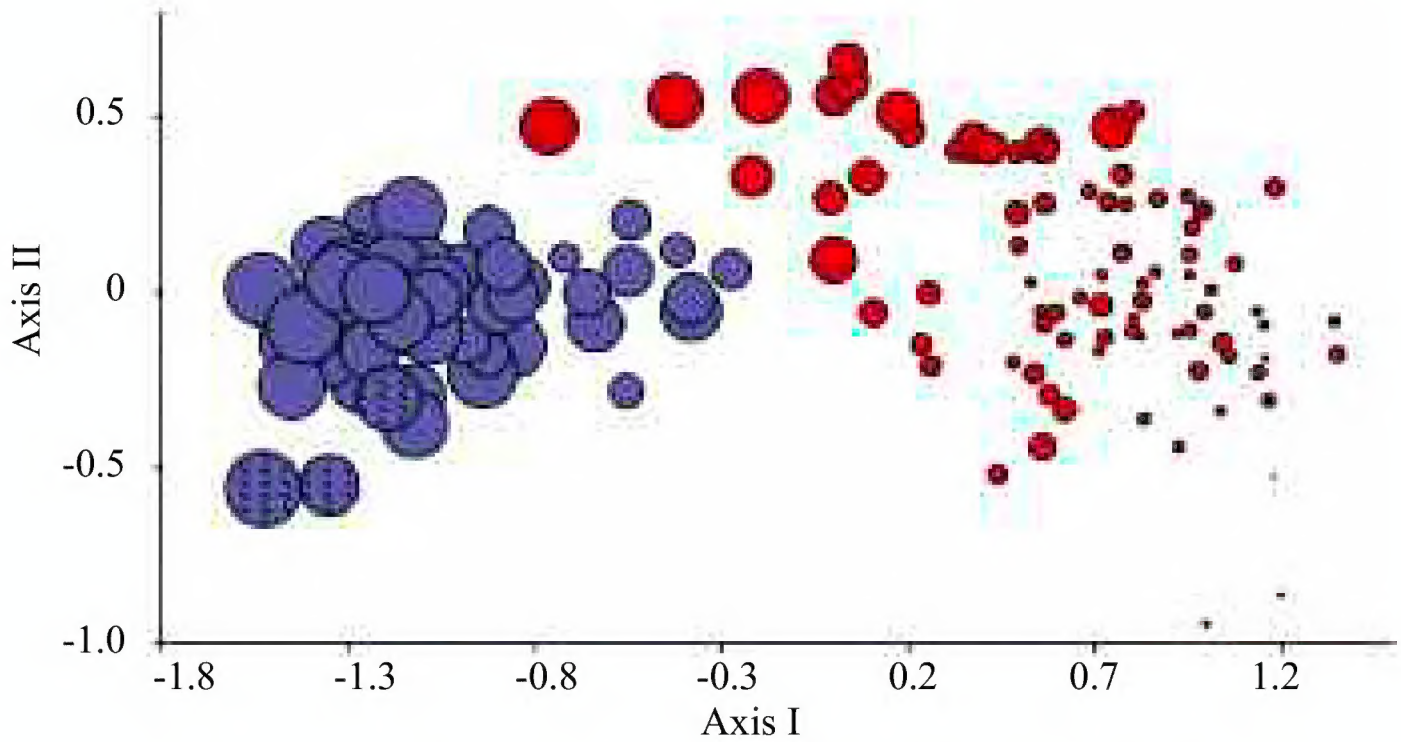

Figure 1. Ordination (NMDS optimised for two dimensions) of 138 transects of 500 m x 5 m in northern Peruvian Amazonia based on their pteridophyte species composition (floristic similarities between two transects calculated with the Jaccard index, i.e. as a proportion of species shared out of the total number of species found in both transects). The transects are plotted such that similar ones are closer together than more dissimilar ones (numeric values on the axes are unimportant). Point size is proportional to the concentration of exchangeable base cations in the soil (Ca+Mg+K+Na, log-transformed) and colours correspond to the two most distinct classes in a cluster analysis based on the floristic similarities. The same division exactly corresponds to the dichotomy between cation-rich clay soils proposed to be of semi-marine origin (in blue) and relatively cation-poor sandy-loamy soils of fluvial origin (in red). Reprinted from figure 2 of Higgins et al. 2011 (the source article is OnlineOpen).

However, aluminium accumulation has been observed in at least two epiphytic species, an *Elaphoglossum* and a *Didymoglossum* (Schmitt et al., 2017). Further studies including more species are needed to clarify if this is actually a phylogenetic effect, since most of the fern epiphytes belong to just a few genera.

Phosphorus and nitrogen

Other soil properties such as phosphorus (P) concentration, loss-on-ignition (LOI) and pH have also been investigated both in the lowlands (Tuomisto et al., 2003a; 2003c; 2016; Costa et al., 2005, Jones et al., 2006; 2013; Moulatlet et al. 2014) and in montane areas (Homeier et al., 2010; Unger et al., 2012). LOI has often had relatively low explanatory power. Phosphorus is among the important plant macronutrients, and some studies have indeed found P to be one of the most important explanatory variables in numerical analyses (Jones et al., 2013; Tuomisto et al., 2016). Other studies have found P to have little explanatory power, however (Tuomisto et al., 2003a; 2003c). This is probably because the Bray method used in these earlier studies to analyse P concentration in the soil samples does not succeed in representing plant-accessible P as well as do the methods used in the more recent studies (e.g., Mehlich III).

Nitrogen is another important plant nutrient that is technically difficult to analyse reliably from soil samples. Furthermore, N concentration in a soil sample can change during storage due to the activity of soil bacteria, unless samples are immediately frozen. Therefore, soil N concentration has not been reported in any of the studies that were carried out in remote rain forest areas. In one study that did report N, it was not among the most important soil variables (Jones et al., 2013). Whether this is because nitrogen is not limiting in the soils of the American tropics (Quesada et al., 2010) or is due to methodological problems remains to be clarified.

In a Hawaiian study (Amatangelo & Vitousek, 2008), leaf N content was found not to vary much among ferns growing on soils with different natural N concentrations. In contrast, leaf P did vary along a soil P gradient and also increased clearly in response to P fertilization. In the Andes, leaf N content was found to be essentially constant within a species along an elevational gradient (Wegner et al., 2003). However, the community-level mean leaf C:N ratio decreased with elevation, even though the C:N ratio in the soil increased.

Texture

Documenting chemical soil properties requires laboratory analyses, but gross soil texture is a characteristic that is easy to observe already in the field. Texture is often related to soil cation concentration, although this relationship is context-specific.

In northern Peruvian Amazonia, the cation-richest soils are heavy clays, intermediate soils are loamy, and the poorest soils consist of coarse white sand (Ruokolainen & Tuomisto, 1998; Higgins et al., 2011). However, in the Yasuni area of Ecuadorian Amazonia, the sandiest soils are not white sands but actually have a higher cation concentration than the loamy soils (Tuomisto et al., 2003a). In central Amazonia, the situation is yet different, because clay soils can there be almost as cation-poor as the white sands (Quesada & Lloyd, 2016). Consequently, it is important to be aware of the local conditions determining soil texture in order to avoid erroneous conclusions. In general, further investigation is still needed to obtain a complete picture of the contributions of different soil variables to explaining pteridophyte species turnover.

Species richness

Not only species composition but also species richness varies along edaphic gradients. Amazonia has relatively low species richness and endemism compared to the montane areas surrounding it, which is probably related to the relatively uniform environment (Tryon, 1985). However, clear species richness gradients have been identified also within Amazonian lowland forests. The highest local species richness seems to be found on the cation-rich soils both at the local (Costa, 2006) and at broader scales (figure 2; Tuomisto & Ruokolainen, 2005; Tuomisto et al., 2014). The broad-scale studies found that also

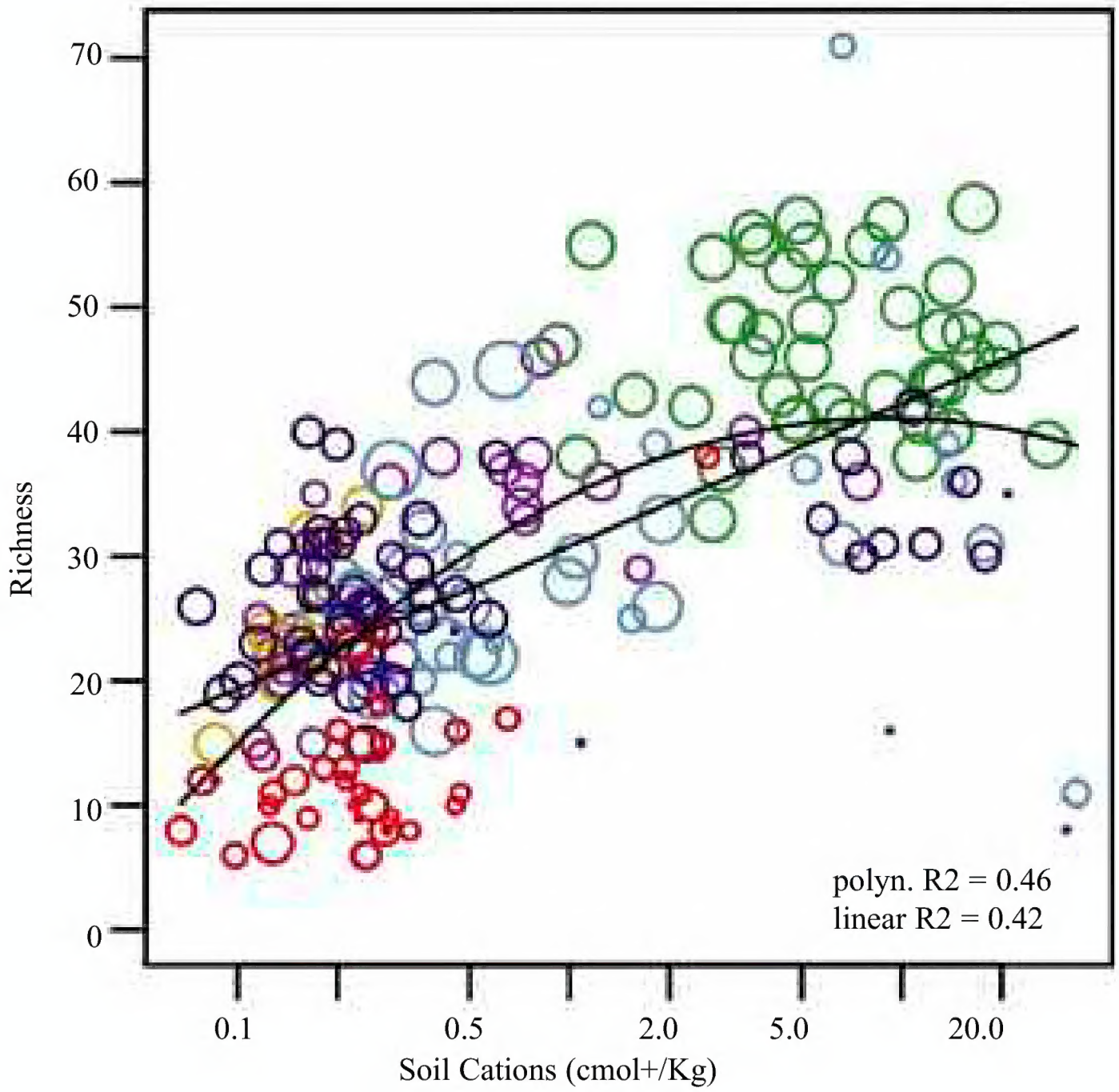

Figure. 2. Trends in species richness (i.e. the number of species) of pteridophytes in 214 transects of 500 m x 5 min Amazonian non-inundated forests as a function of measured concentration of exchangeable base cations in the soil. Colours refer to geographical regions: green, Ecuador; orange, Colombia; red, central Amazonia; dark blue, NW Peruvian Amazonia; purple, NE Peru; mid blue, central Peru; light blue, S Peru. The most distant sites are more than 2000 km apart. Symbols are sized in relation to annual rainfall (extracted from WorldClim v. 1.4), which is only weakly correlated with soil cation concentration (r = 0.21). Reprinted, with permission, from figure 5 of Tuomisto et al. (2014).

aluminium concentration and the local variability in both Al and base cations correlate with pteridophyte species richness. Moreover, the species pool of pteridophytes seems to be larger on cation-rich than cation-poor soils (Tuomisto & Poulsen, 1996; Tuomisto et al., 2014). High pteridophyte species richness is also related to high annual rainfall, so highest average species richness is found on fertile soils in wet climates (Tuomisto et al., 2014).

Topography and hydrology

In addition to soil nutrients, water availability and soil drainage are important determinants of plant species distributions. Soil moisture varies with local topography, such that low-lying sites are generally moister and more prone to waterlogging than sites at higher topographic positions, which in turn may be susceptible to drought. In Amazonia, seasonality in rainfall causes considerable fluctuation in the water level of rivers (from a few to more than 10 m), which causes extensive areas of forest in the river floodplains to become seasonally inundated. Along the margins of the floodplains there are often swamp forests, which have waterlogged soils even during the low-water season.

A prolonged period of inundation is stressful for plants because it causes hypoxia in the soil and prevents photosynthesis in the submerged parts of the plant (e.g., Pires & Prance, 1985; Parolin, 2009). Specific adaptations are needed for plants to tolerate such conditions, which is reflected in dissimilar species composition between the inundated and non-inundated (the latter is known as 'terra firme') forests (Balslev et al., 1987; Kahn, 1987). These contrasting habitats are clearly distinct also in terms of pteridophyte species composition (Tuomisto et al., 2003c; Salovaara et al., 2004), and pteridophyte species richness in the inundated forests seems to be relatively low (Tuomisto & Ruokolainen, 2005). Most species that have been reported to be typical of seasonally inundated forests are epiphytic or hemiepiphytic, which allows them to at least partly escape the inundation (e.g. *Campyloneurum fuscosquamatum* Lellinger, *Lomagramma guianensis* (Aubl.) Ching, *Polybotrya caudata* Kunze, *P. glandulosa* Mett. ex Kuhn and *Salpichlaena hookeriana* (Kuntze) Alston) (van der Werff, 1992; Salovaara et al., 2004). Although non-inundated forests are not affected by floods from rivers, they, too, contain a hydrological gradient from the wet valley bottoms and creeksides to the drier hill tops and ridges. Corresponding gradients in pteridophyte species composition have been reported in several studies both for Amazonia (Tuomisto & Ruokolainen, 1994; Tuomisto et al., 1995; Tuomisto & Poulsen, 2000; Vormisto et al., 2000; Costa, 2006; Poulsen et al., 2006; Drucker et al., 2008; Moulatlet et al., 2014) and for Central America (Jones et al., 2006; 2007; 2016). Although most pteridophytes seem to avoid waterlogged areas, moist and even sporadically inundated sites along creeks have often had high pteridophyte species richness in western Amazonia (Tuomisto & Ruokolainen, 1994; Tuomisto et al., 1995; Tuomisto & Poulsen, 2000; Poulsen et al., 2006). Slopes have been found to have high species richness and abundance in a central Amazonian study (Costa, 2005).

Often it is difficult to disentangle the possible causal factors behind observed pteridophyte species distribution patterns along topographical gradients. This is because local topographic variation can be related to factors other than soil moisture, in particular soil nutrient concentration, soil texture and light intensity at the forest floor. How such factors interact is always somewhat idiosyncratic, as it depends on the geological history of the area: the sources and mineralogy of the soil parent material as well as the different sedimentation, erosion and weathering processes that have affected it (Chauvel et al.,

1987; Vormisto et al., 2004; Chadwick & Asner, 2016). For example, white sand soils are not only nutrient-poor, but they have a low water holding capacity (which causes them to dry out quickly during dry spells) and may have a hard pan as well (which makes them even more drought-prone but in addition causes them to become waterlogged when it rains). Ridges are the most exposed part of the local topography and receive more light than do slopes and valleys. However, the amount of light that reaches the understory, where data on pteridophytes have predominantly been collected, depends also on vegetation structure and especially the presence of canopy gaps. In western Amazonia, white sands tend to be situated on the hill tops or upper plateaus, which renders them more prone to drought than in central Amazonia, where the white sands are usually found along creeks (Tuomisto & Ruokolainen 1994; Vormisto et al., 2004; Costa et al., 2005; Chadwick & Asner, 2016).

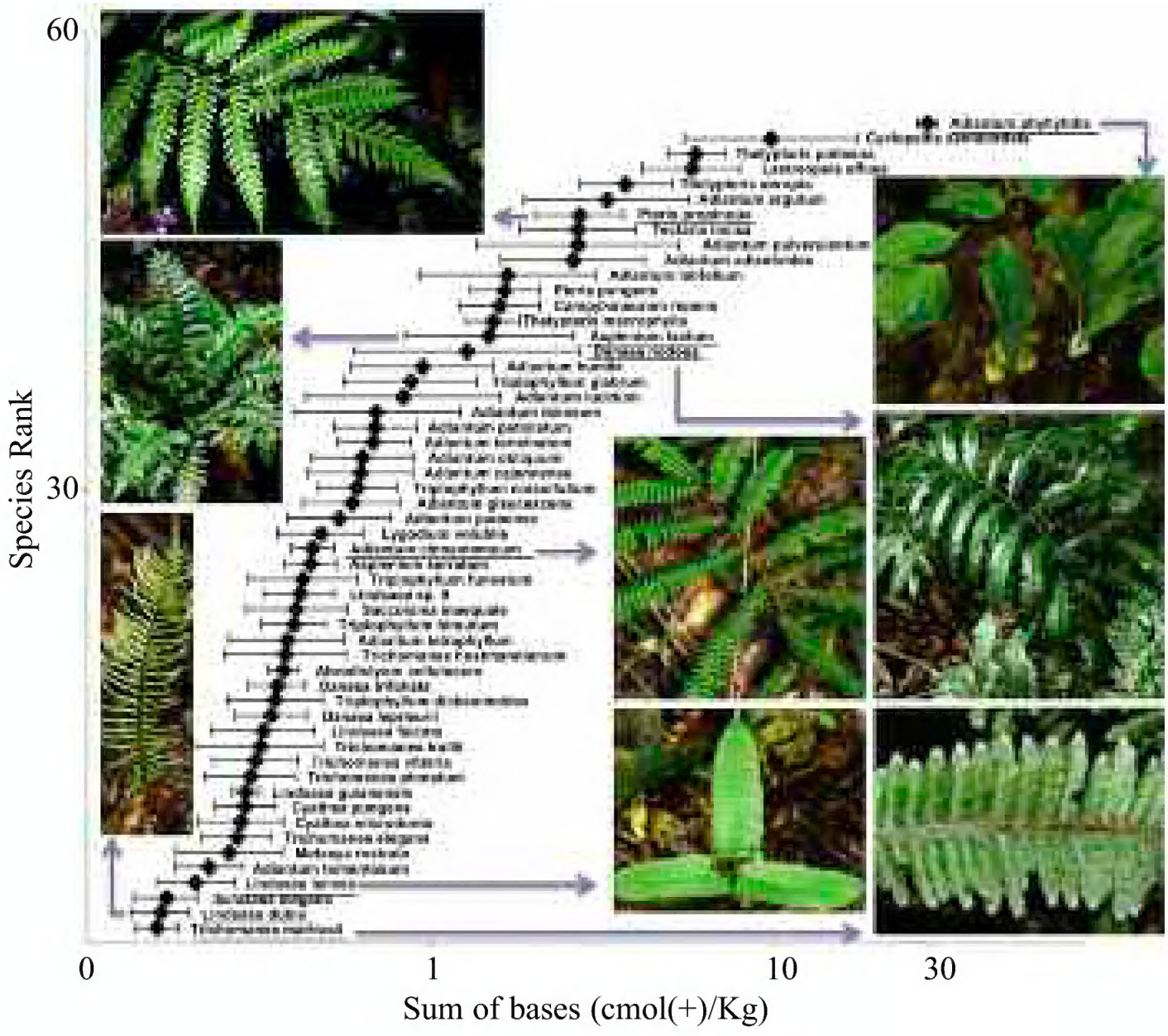

Figure 3. Optima and tolerances of fern species along a gradient of soil exchangeable base cation concentration (sum of bases) as estimated using data from 305 plots in Brazilian Amazonia. The most distant sites are more than 2000 km apart. The x axis is in logarithmic scale. Example of white-sand species is *Trichomanes martiusii*, which typically grows in low-nutrient white-sand patches. Rich-soil species, like *Adiantum phyllitidis* J.Sm., typically grow on clay soils. Reprinted, with permission, from figure 3 of Zuquim et al. 2014.

SPECIES DISTRIBUTIONS ALONG EDAPHIC GRADIENTS

As discussed above, pteridophyte species present general and clear species turnover along a soil cation concentration gradient. This emerges from the behaviour of the individual species, many of which are specialised to just a limited part of the soil cation concentration gradient (figure 3) (e.g., Tuomisto & Poulsen, 1996; Tuomisto et al., 2002; Cárdenas et al., 2007; Zuquim et al., 2014; Moulatlet et al., 2017).

It has been documented that different species within the same genus can present specialisation to different parts of edaphic gradients, suggesting niche partitioning within genera. For example, six species of the terrestrial genus *Adiantum* in Peruvian and Ecuadorian Amazonia could be grouped into three distribution types (Tuomisto et al., 1998): one species (*A. tomentosum* Klotzsch) was found only in relatively cation-poor loamy to sandy soils, four (*A. humile* Kunze, *A. obliquum* Willd., *A. terminatum* Kunze ex Miq., *A. tetraphyllum* Humb. & Bonpl. ex Willd.) were relatively broadly distributed on intermediate soils, and one (*A. pulverulentum* L.) was exclusively found on the most cation-rich soils. This pattern has remained consistent in other studies that have looked at the distributions of the same *Adiantum* species along the soil cation concentration gradient (Tuomisto & Poulsen, 1996; Tuomisto et al., 2002; 2016; Cárdenas et al., 2007; Higgins et al., 2011; Zuquim et al., 2014; Moulatlet et al., 2017). *Adiantum pulverulentum* has also been found in the nutrient-rich anthropogenic dark-earth soils in Bolivia (Quintero-Vallejo et al., 2015). These examples from areas more than 1000 km apart suggest that the soil preferences are consistent across the Amazon basin.

Another genus whose species have been found to be clearly differentiated along edaphic gradients in Amazonia is the hemiepiphyte genus *Polybotrya* (Tuomisto, 2006). This genus has two species restricted to cation-rich soils (*P. crassirhizoma* Lellinger and *P. fractiserialis* (Baker) J.Sm.), two found on intermediate soils (*P. caudata* and *P. osmundacea* Humb. & Bonpl. ex Willd.), one on relatively cation-poor soils (*P. pubens* Mart.) and two on very cation-poor soils (*P. sessilisora* R.C.Moran and *P. glandulosa*). In addition, the species segregate along a hydrological gradient: *P. caudata* and *P. glandulosa* occur in swamps and in seasonally inundated areas along streams, *P. sessilisora* occurs mainly on hill tops, and the other species are intermediate.

It has been found that even within the relatively local scale of La Selva biological station in Costa Rica, different species of ferns show different distributional patterns along gradients of soil chemistry and topography (Jones et al. 2007; 2008).

Our understanding of edaphic specialisation in pteridophytes is advancing in parallel with taxonomic progress and data accumulation. For example, the terrestrial genus *Metaxya* was thought to be monotypic, but now it is known to include at least six species. One of these is specialised to very nutrient-poor white sand soils, and its edaphic distribution is therefore clearly segregated from the other species, even though its geographical distribution overlaps with two of them (Cárdenas et al., 2016).

A similar case was found for two species of the mainly terrestrial genus *Lindsaea*. *Lindsaea divaricata* Klotzsch has traditionally been considered a widespread generalist species, but ecological field work in Amazonia revealed that the populations on edaphically different sites have subtle morphological differences, especially at the juvenile stage. It turned out that *L. divaricata* itself only occurs on very nutrient-poor sites, such as white sand soils and peat bogs, and the form growing on loamy soils is a different species, *Lindsaea digitata* Lehtonen & Tuomisto (Lehtonen & Tuomisto, 2007). Several fern genera show strong edaphic niche conservatism to either poor or rich soils, whereas many other genera have radiated to span a rather broad edaphic range (Lehtonen

et al., 2015). Both *Adiantum* and *Trichomanes* have species on various kinds of soils, but their overall distributions have been found to be biased such that *Adiantum* is mostly a rich-soil lineage and *Trichomanes* mostly a poor-soil lineage (Lehtonen et al., 2015). Some other genera are more uniform in their edaphic distribution. For example, all species of the genera *Bolbitis*, *Pteris* and *Tectaria* seem to be restricted to rich soils in Amazonia, whereas in the mostly rich-soil *Thelypteris s.l.* there are a few exceptions (with the most notable one being *Thelypteris (Meniscium) macrophylla* (Kunze) C.V.Morton on intermediate soils). In contrast, all species of *Triplophyllum* and *Schizaea* and almost all species of *Lindsaea* are restricted to poor soils (Tuomisto & Poulsen, 1996; Tuomisto, 1998; León et al., 2005; Lehtonen et al., 2015). For a long time, *Tectaria brauniana* (H. Karst.) C.Chr. seemed to be an odd *Triplophyllum*-like poor-soil species within an otherwise rich-soil genus, but eventually molecular phylogenies showed that it belongs to the genus *Hypoderris*, which is sister to *Triplophyllum* (Moran et al., 2014; Wang et al., 2014).

BIOGEOGRAPHICAL AND EVOLUTIONARY CONSEQUENCES

Strong soil specificity restricts the occurrences of a pteridophyte species to sites representing its favoured kinds of soil. When the soil properties themselves are regionally distributed such that different areas are geochemically different, this may lead to patterns of biogeographical magnitude, with different regions having different pteridophyte species pools (Tuomisto et al., 2016). Tryon and Conant (1975) observed that Brazilian Amazonia has a lower diversity of the terrestrial genera *Thelypteris* and *Pteris* than do surrounding areas. This is consistent with these genera being mostly found on cation-rich soils, which in turn are rather rare and restricted to small patches in central Amazonia (Tuomisto & Poulsen, 1996; Zuquim et al., 2009).

In both Peruvian and western Brazilian Amazonia, a steep turnover of pteridophyte species has been documented across the limit between two geological formations, one of which consists of relatively cation-rich clays and the other one of cation-poor loamy soils (Higgins et al., 2011 in Peru; Tuomisto et al., 2016 in Brazil). In the Peruvian area, the borderline between the two formations is identifiable in satellite imagery for a distance of more than 200 km, and in the Brazilian area, for about 1000 km. In each area, the species turnover patterns were similar, and a larger number of pteridophyte species and genera was found on the formation with the higher concentration of base cations. Although such boundaries between soil types do not form physical dispersal barriers, they may nevertheless effectively function as such and restrict the distributions of specialist species.

Furthermore, such an edaphic barrier can cause differential selection pressures on the two contrasting surfaces. The observed edaphic segregation among congeneric fern species has indeed inspired the suggestion that speciation in Amazonia may have been driven in part by mechanisms of geographic isolation (allopatric speciation) but also by reproductive isolation caused by abrupt discontinuities of soil conditions (i.e. parapatric or sympatric speciation; Tuomisto et al., 1998; Tuomisto, 2006; 2007). This hypothesis has not yet been tested for pteridophytes using well-resolved phylogenies, but results from analyses involving other Amazonian plant groups have supported the idea (Schulman et al., 2004; Fine et al., 2005; Fine & Kembel, 2011).

PRACTICAL APPLICATIONS OF PTERIDOPHYTE-SOIL RELATIONSHIPS

An important practical application emerging from the edaphic specificity of pteridophyte

species is that they can be used as indicator species for habitat classification and mapping, which are essential for conservation planning. Soil heterogeneity causes variation in the floristic composition of forests that is not necessarily reflected in easily detectable changes in forest structure (Suominen et al., 2015). For example, Amazonia is mostly covered in dense terra firme rainforests, the classification of which into more accurately defined forest types is not a trivial task (Pires & Prance, 1985; Duivenvoorden & Lips, 1995). To some extent, habitat classification can be done solely on the basis of differences in soil conditions (Duivenvoorden & Lips, 1995), but taking into account also floristic information may give ecologically more meaningful results (Ferrier, 2002).

Although habitat specificity is common in other plant groups as well (e.g., trees, palms and Melastomataceae; Ruokolainen et al., 1997, 2007; Vormisto et al., 2000, 2004; Phillips et al., 2003; Tuomisto et al., 2003a; 2003b; 2003c; 2016; Baldeck et al., 2013; 2016), pteridophytes have advantages that make them an especially good indicator group. Most importantly, pteridophytes are relatively easy and quick to sample, especially compared to trees: the individuals are of a convenient size and easily accessible in the forest understorey (if canopy epiphytes are ignored), the number of species is manageable, and most genera and species are easy to identify on the basis of gross morphology (Ruokolainen et al., 1997; 2007; Kessler & Bach, 1999; Tuomisto et al., 2003c; Duque et al., 2005; Zuquim et al., 2009; 2017).

Given that many tropical forest areas are difficult to access, remote sensing has been used to identify patterns in vegetation and soil heterogeneity. The interpretation of satellite images needs to be supported by field verification, and several studies have used pteridophytes for the purpose of validating observations based on Landsat TM/ETM+ images (Tuomisto et al., 1995; 2003a, 2003b; Salovaara et al., 2005; Higgins et al., 2011; 2012) and LiDAR data (Higgins et al., 2015). Combining information on pteridophyte-soil relationships with remote sensing opens a large set of applications. Rajaniemi et al. (2005) used satellite images to produce predictive maps of the species richness of pteridophytes and Melastomataceae, including maps for subsets with different edaphic preferences. Salovaara et al. (2005) used pteridophyte inventories and satellite imagery to produce a habitat map for mammal surveys. Zuquim et al. (2014) tested the use of pteridophytes as indicators of different soil properties, and found that their predictive power was best for the concentration of exchangeable base cations. Sirén et al. (2013) used known pteridophyte optima for soil cation concentration to produce a map indicating variation in potential site productivity, which can be expected to be related with game animal population density and carrying capacity, to support local decision-making on where to apply hunting restrictions to ensure sustainability of hunting.

Several digital soil maps have been published that can be used in species distribution modeling and other applications (SOTERLAC [FAO 2006], SoilGrids [Hengl et al. 2007], HWSD [Nachtergaele et al. 2012]). Although these have been found to improve the performance of fern species distribution models above that of models based on climatic data only (Figueiredo et al., 2018), they are based on scant field data, so their accuracy at fine scales varies considerably. Moulatlet et al. (2017) used field data on soils and pteridophytes to test the accuracy of these maps, and found that they had only limited capacity to reconstruct the known edaphic preferences of thirteen fern species (*Adiantum pulverulentum, Adiantum tomentosum, Cyathea pungens* (Willd.) Domin, *Cyclopeltis semicordata* (Sw.) J. Sm., *Lindsaea guianensis* (Aubl.) Dryand., *Pteris pungens* Willd., *Saccoloma inaequale* (Kunze) Mett., *Schizaea elegans* (Vahl) Sw.,

Thelypteris macrophylla, Trichomanes elegans Rich., and *Trichomanes martiusii* C.Presl).

FUTURE PROSPECTS AND RECOMMENDATIONS

Our knowledge of species–soil relationship has significantly increased in the past few decades. However, the tropical American forests cover a vast area, and the distribution of both pteridophyte and soil diversity is still largely unknown. In particular, there is need for more collections to fill the existing data gaps (figure 4; Feeley, 2015). The digital revolution of the past 10 years has also affected soil and plant sciences (Hartemink & McBratney, 2008; Peterson et al., 2010; Hardisty & Roberts, 2013): species records and taxonomic information have been compiled into online databases, herbarium collections have been digitalised and made available online, and mapping techniques have been developed.

Access to plant records has improved dramatically. Many herbaria have made their collections available online, and almost one million geo-referenced pteridophyte observations are accessible through the Global Biodiversity Information Facility (www.gbif.org), which provides an interface to the digital databases of herbaria worldwide. Currently, nearly 50,000 pteridophyte observations from South America are accessible through GBIF (figure 4). These data can give valuable information on pteridophyte occurrences at the broad scale, and thereby facilitate biogeographical and macroecological inferences. In addition, the increasing access to fern data in online

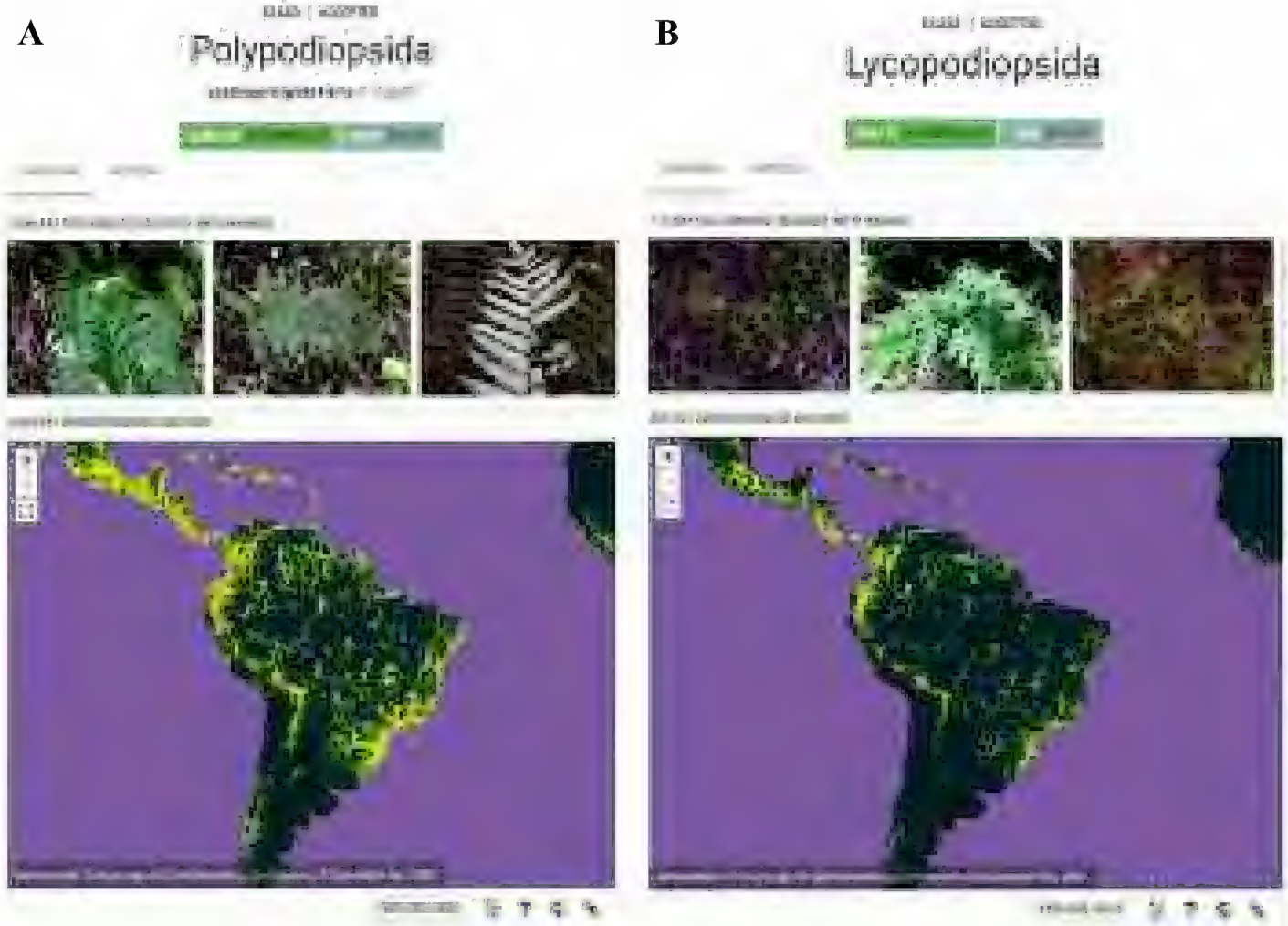

Figure 4. Density of **A:** Polypodiopsida and **B:** Lycopodiopsida records available in the Global Information Facility (GBIF - www.gbif.org). Dark green indicates that there are no collections available, shades from yellow to red indicate increasing density of collections. Retrieved on the 30th of May 2018.

portals helps to identify the data voids and to target the collection of new field data to unsampled areas (Feeley, 2015). Unfortunately, the accuracy of the geographic coordinates provided with the observations is variable. Even when a careful data-cleaning step is implemented, one cannot count on high geo-referencing accuracy in the GBIF data.

Individual researchers and other interested persons can share their digital collections (photographs) and taxonomic information globally through the Ferns and Lycophytes of the World portal (*www.fernsoftheworld.com*). Currently, this portal contains photographs of nearly 1000 species. However, the total area inventoried still represents a very small portion of the American tropics. The impact of collection density on the observed pteridophyte species richness has been documented in Bolivia, where the number of known species has increased dramatically during a project aiming to document the pteridophyte flora of the country (Soria-Auza & Kessler, 2008). Such trends have an impact on the global species richness estimates as well: while ca. 9,000 fern species are currently known worldwide, it has been estimated that 15,000 may exist (Kessler, 2010). Indeed, compilations of fern richness show that the number of species keeps increasing (Prado et al., 2015).

It seems that the relationships between pteridophytes and soils in the American tropics have mostly been studied in Amazonia, and to some degree in Central America. We did not find studies explicitly addressing soil characteristics in other rainforest areas in the American tropics, such as the Atlantic rainforest of Brazil or montane forests in the Andes. Although collecting and transporting soil samples takes some effort, and laboratory analyses are expensive, the existence of soil data significantly adds value to the pteridophyte data as well. In particular, following already used protocols would allow data to be combined across studies in order to build a broader view of community ecology and biogeography not only of pteridophytes themselves but of tropical forests in general. One possible strategy to improve our knowledge on pteridophyte distributions is to crowdsource data collection by involving non-scientists. Citizen science is emerging as an important way not only to increase the number of observations but also to engage the society and to raise public awareness of nature. This approach is facilitated by the existence of online platforms, such as iNaturalist (inaturalist.org), which allows easy uploading and curation of data by any interested person. We have recently started a campaign to collect data on pteridophytes in Amazonia (https://www.inaturalist.org/projects/samambaias-helechos-ferns-amazonia), and encourage everyone who visits the area to participate, or to start their own campaigns in other areas.

The forests in tropical America face high deforestation rates (Watson et al., 2018), and some areas, soil types and forest types may be more at risk than others (Laurance et al., 2002). A broad picture of both species distributions and species–soil associations is needed to understand the ecology, biogeography and evolution of pteridophytes in the tropics. Such information can help conservation and the planning of sustainable use of forest resources.

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SHORT BIOGRAPHIES OF THE AUTHORS

Gabriel M. Moulatlet was born in São Paulo, Brazil on 20 April 1987 and spent his childhood in the countryside town of Itapeva. He studied biology at the University of the State of São Paulo (UNESP) and then moved to Manaus to obtain his master´s degree from the Brazilian National Institute of Amazonian Research (INPA). It was at INPA where he started to study ferns, inspired by his supervisor Flavia Costa. He graduated with a thesis that investigated the spatial distribution of understorey herbs along hydrological gradients in Central Amazonia. After finishing his thesis he was invited by Hanna Tuomisto to participate in a 3-month boat expedition along the Juruá River in Brazilian western Amazonia. The successful trip resulted in an invitation to go to Finland for a year to work with the Amazon Research Team of the University of Turku. His stay in Finland was extended to five years, during which he was involved in several scientific publications, participated in field expeditions to the Amazon and did a PhD degree. Currently, he is back to the Amazon, living in Ecuador, teaching and researching and supervising students at the Universidad Regional Amazónica Ikiam. His interests are in biogeographical and ecological aspects of ferns and other plant groups of tropical forests and their relationship with soil and hydrological conditions.

Gabriela Zuquim was born in São Paulo, Brazil on 22 July 1981. After obtaining a

degree in Biology at the University of São Paulo in 2003, she moved to Manaus, Brazil, to enroll in a master degree program in Ecology at the National Institute of Amazonian Research (INPA). She completed her degree in 2006. Between 2006 and 2010, she collected fern data over five states of the Brazilian Amazonia, in research sites established by the Brazilian Research Program on Biodiversity Research (PPBio). She made a comprehensive sampling of the, until then, widely unknown pteridoflora of Uatumã region, central Amazonia that resulted in a richly illustrated field guide published in 2008. In 2011, she moved to Finland to carry out PhD studies in ecology at the University of Turku. Her doctoral thesis was on the diversity patterns and usefulness of ferns and lycophytes as habitat indicators in Amazonia. During her PhD, she also produced an online key to Amazonian ferns. She completed her PhD in 2015 and continues as a post-doctoral researcher at the University of Turku. She is interested in modelling Amazonian species distribution in the present and in the future.

Hanna Tuomisto was born in Helsinki, Finland, on 4 May 1965. She studied botany at the University of Helsinki, and interrupted the studies for half a year to set off with fellow student Kalle Ruokolainen to explore the biological wonders of Peru. Both were fascinated by Amazonian rain forests, and went on to study tropical ecology for a year at Aarhus University, Denmark. After finishing their MSc degrees in 1990, they joined the Amazon Research Team at the University of Turku to pursue PhD studies in the heterogeneity of Amazonian forests and how geological history and soil properties might be linked to plant species distributions and speciation. Since she obtained her PhD in 1994, her research has included not only floristic studies but also taxonomy, molecular phylogeny and biogeography of ferns, as well as remote sensing and conceptual studies related to beta diversity. She enjoys field work and has carried out numerous expeditions to remote parts of Amazonia.

DRYOPTERIS ×*COMPLEXA* NOTHOSUBSP. *TRANSSILVANICA*: A NEW HYBRID FROM THE CARPATHIANS (DRYOPTERIDACEAE, POLYPODIOPHYTINA)

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Key words: *Dryopteris affinis* agg., new tetraploid hybrid, morphology, flow cytometry

ABSTRACT

During field studies in the Romanian Southern Carpathians and the Polish Western Carpathians, a new tetraploid fern hybrid was discovered. This taxon is described as *Dryopteris* ×*complexa* nothosubsp. *transsilvanica* (*Dryopteris affinis* subsp. *jessenii* × *D. filix-mas*). The macroscopic identification is supported by flow cytometric and earlier cytological results.

INTRODUCTION

The *Dryopteris affinis* group represents a difficult research subject due to its high morphological resemblance, which causes numerous problems even for fern specialists. The best taxonomy so far was done by Fraser-Jenkins (2007), who described six species: *D. affinis* (Lowe) Fraser-Jenk. s. str. (diploid apomict, 2*n*=82) and five triploid apomicts (2*n*=123): *D. borreri* (Newman) Newman ex Oberh. & Tavel, *D. cambrensis* (Fraser-Jenk.) Beitel & W.R.Buck, *D. pseudodisjuncta* (Tavel ex Fraser-Jenk.) Fraser-Jenk., *D. schorapanensis* Askerov and *D. pontica* (Fraser-Jenk.) Fraser-Jenk.

However, the final number of taxa in this group cannot yet be determined since ongoing research may lead to new discoveries, such as the recent description of *D. lacunosa* S.Jess., Zenner, Chr.Stark & Bujnoch (Jeßen et al., 2011).

Within the diploid species *Dryopteris affinis*, five subspecies are currently described: *D. affinis* subsp. *affinis*, *D. affinis* subsp. *paleaceolobata* (T.Moore) Fraser-Jenk., *D. affinis* subsp. *punctata* Fraser-Jenk., *D. affinis* subsp. *kerryensis* (Fraser-Jenk.) Fraser-Jenk. and *D. affinis* subsp. *jessenii* (Fraser-Jenk.) Fraser-Jenk. Until now only three tetraploid hybrids have been described that involve the first three of these diploids taxa, with *Dryopteris filix-mas* (L.) Schott (tetraploid sexual, 2*n*=164) as the second parent: *D.* ×*complexa* Fraser-Jenk. nothosubsp. *complexa* (Portugal, Spain, France, Belgium, Great Britain, Ireland, Germany, Switzerland, Italy, Austria, Romania), *D.* ×*complexa* nothosubsp. *contorta* Fraser-Jenk. (Great Britain), *D.* ×*complexa* nothosubsp. *eschelmuelleri* Fraser-Jenk. (Germany, Switzerland, Croatia, Turkey) (Fraser-Jenkins, 2007).

Here we report a fourth hybrid between a subspecies of *Dryopteris affinis* s. str. and *D. filix-mas*: *D. affinis* subsp. *jessenii* × *D. filix-mas* (Figure 1 and 2) discovered in the Romanian Southern Carpathians and the Polish Western Carpathians.

Figure 1. *Dryopteris* ×*complexa* nothosubsp. *transsilvanica*, SJ-1310, Romania, Northern-Făgăraş Mts: Şerbota valley, ca. 750 m a.s.l., in culture in Chemnitz since 1985; Photo: S. Jeßen 12.06.2016

Figure 2. Leaf fragment from the central part of the lamina of *Dryopteris* ×*complexa* nothosubsp. *transsilvanica* from a natural locality, Poland, the Little Beskid: Hrobacza Meadow, ca. 620 m a.s.l.; Photo: D. Tlałka 23.07.2016

MATERIALS AND METHODS

The field research was conducted in the Romanian Southern Carpathians in 1985 (Jeßen, 1991). Specimens collected during this field trip were cultured in Chemnitz (Germany) (Figure 3). Field studies in the Polish Western Carpathians were conducted in 2015–2017, where a further locality for the taxon was discovered by the first author in 2015 and the voucher is in KTU (Figure 4).

The ploidy of the specimen was investigated by flow cytometry. Young leaf fragments of *D. filix-mas* (tetraploid sexual, 2*n*=164), *D. affinis* subsp. *jessenii* (diploid apogamous, 2*n*=82) (Bär & Eschelmüller, 2007) and the new hybrid were chopped separately with a razor blade in a Petri dish containing 400 µl of nuclei extraction buffer (Nuclei Extraction Buffer, CyStain® UV Precise P Kit, Sysmex 05-5002). The resulting nuclei suspension was filtered through a 30 µm mesh (CellTrics, Sysmex) in to a clean tube and incubated for 30 min at RT. In the next step, 1600 µl of staining buffer containing DAPI (Staining Buffer, CyStain® UV Precise P Kit, Sysmex 05-5002) with β-mercaptoethanol (2µl/ml, Sigma) were added. Samples were incubated for 5 min at room temperature in the dark and subsequently analysed using a CyFlow Space Sysmex flow cytometer equipped with a 365 nm UV laser diode as light source. For each taxon two individual samples were prepared and analysed twice.

ECOLOGY

The new hybrid was observed in two localities at 580–750 m above sea level, on slopes of gorges overgrown by beech forests. The presence of the Luzulo luzuloidis-Fagetum community has also been confirmed in the Western Carpathians.

Phytosociological relevé: 11.06.2017; the Little Beskid Mts.; Hrobacza Meadow; slope 40 % N; 620 m a.s.l.; area 100 m²; tree layer (A): 100 %; shrub layer (B): 1 %, herb layer (C): 30 %.

A: *Fagus sylvatica* 95%. B: *Fagus sylvatica* 5%. C: *Dryopteris dilatata* 10%; *D. affinis* subsp. *jessenii* 3%; *D. affinis* subsp. *jessenii* × *D. filix-mas* 1%; *D. borreri* 1%; *Athyrium filix-femina* 5%; *Oxalis acetosella* 5%; *Carex sylvatica* 1%; *Abies alba* 3%; *Acer pseudoplatanus* 3%; *Rubus* spec. 3%; *Luzula luzuloides* 5%.

RESULTS

The new hybrid has characters morphologically intermediate between *D. affinis* subsp. *jessenii* and *D. filix-mas*. The leaves taper towards the base and the apex, are up to 140 cm long, matt and light to dark green in colour. The spot at the pinna-midrib base (on living specimens) is slightly faint and fades towards the top of the lamina as in *D. affinis* subsp. *jessenii*. Pinna-segment (pinnule) shape at the tip ranges from straight cut as in *D. affinis* subsp. *jessenii* to rounded as in *D. filix-mas*. Scales are black-brown at the base as in *D. affinis* subsp. *jessenii* but light to dark brown towards the top as in *D. filix-mas* (Figure 5). Spores are mostly deformed and abortive, and only rarely well formed, as it is typical for hybrids involving apomict taxa (Figure 6). The hybrid shows great morphological similarity with other tetraploid subspecies of *D.* ×*complexa*, from which it differs by the presence of straight cut tips of the pinna-segments (pinnules) with strong teeth (Table 1).

To estimate the ploidy level of the hybrid, flow cytometry was used. The two parental taxa with known ploidy levels – diploid (2*n*=82) for *D. affinis* subsp. *jessenii* and tetraploid (2*n*=164) for *D. filix-mas* (Ekrt et al. 2009) were used as references to determine the peaks position. The nuclear peak of the hybrid corresponding to the 2C

Figure 3. Holotype of *Dryopteris* ×*complexa* nothosubsp. *transsilvanica* – SJ-1310 (JE); scale = c. 20 cm; Photo: S. Jeßen

Figure 4. *Dryopteris* ×*complexa* nothosubsp. *transsilvanica* – herbarium KTU specimen; Photo: A. Rostański

A. *Dryopteris affinis* subsp. *jessenii*. **B.** *D.* × *complexa* nothosubsp. *transsilvanica*. **C.** *D. filix-mas*

Figure 5. Comparison of leaf morphology of plants from Poland. Photos: A. Rostański

DNA content was found at the same position as the peak for the tetraploid *D. filix-mas* (Figure 7 A, B). In contrast, the 2C peak of the diploid taxon *D. affinis* subsp. *jessenii* had half the fluorescence intensity (Figure 7, value 10 on the × scale for *D. affinis* subsp. *jessenii* (Figure 7 C) compared with 20 for *D. filix-mas* and the hybrid). These results show that the hybrid taxon is tetraploid, which is the usual ploidy level found in hybrids between *D. affinis* and *D. filix-mas* (Bär & Eschelmüller, 2006, Fraser-Jenkins, 2007). Each sample was measured twice and no changes in peak position were observed. To confirm these data, analysis included an internal reference standard (*Vicia faba*).

A specimen of the hybrid from Romania (SJ-1303) was studied flow-cytometrically by J. Fuchs (Gatersleben). *Secale sereale* was the reference standard. Four measurements were made. The result gave 32.05 pg / 2C, this value being in the range of the other *Dryopteris* tetraploids examined at the same time, e.g. *D. filix-mas*, SJ-2818, showed 31.78 pg / 2C.

DISCUSSION

The discovery of the hybrid at just two localities is probably related to an insufficient penetration of the terrain by researchers and with difficulties in the precise identification of this taxon. Other factors may include infrequent hybridisation between species within the genus *Dryopteris* and the rarity of one of the parental taxa – *D. affinis* subsp. *jessenii*. Until recently *D. affinis* subsp. *jessenii* was known only from Romania (Transylvanian Alps: Northern Făgăraş Mountains, Bîlea valley and Şerbota valley; Jeßen, 1985 as *D. affinis* subsp. *borreri* var. *splendens*; Jeßen, 1991 as an undescribed var. of subsp. *affinis*; Banat: Băile Herculane; Widén et al., 1996) and from Serbia (Novi Pazar; Widén et al.,

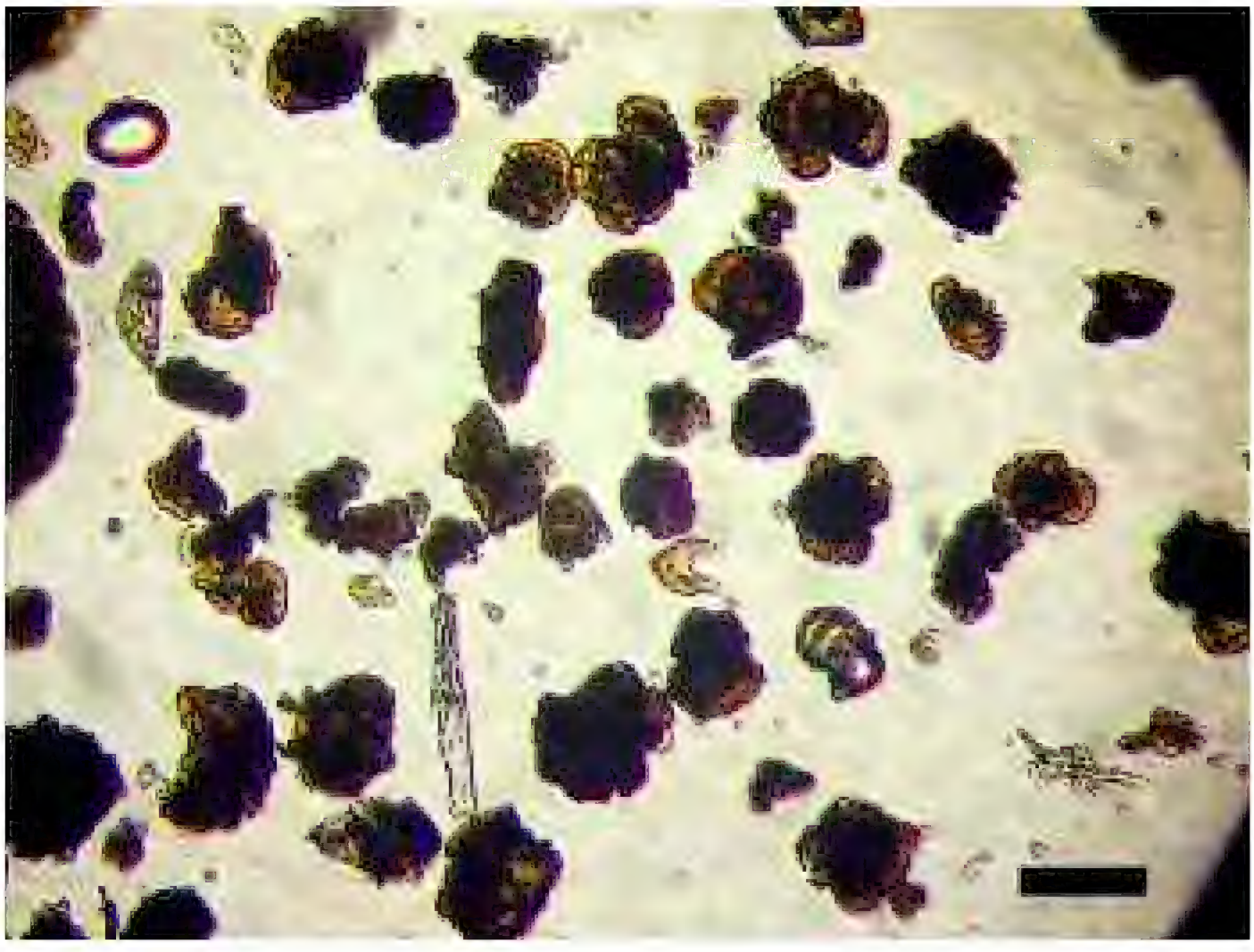
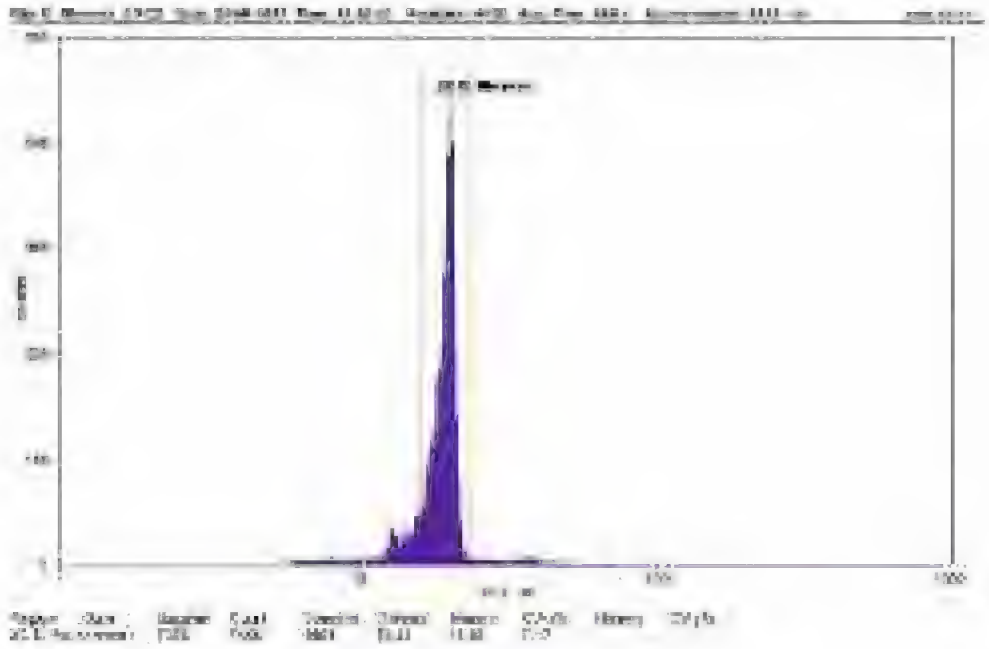


Figure 6. Sporangium content of SJ-1310; the spores are clearly abortive; scale = c. 50 µm; Photo: S. Jeßen

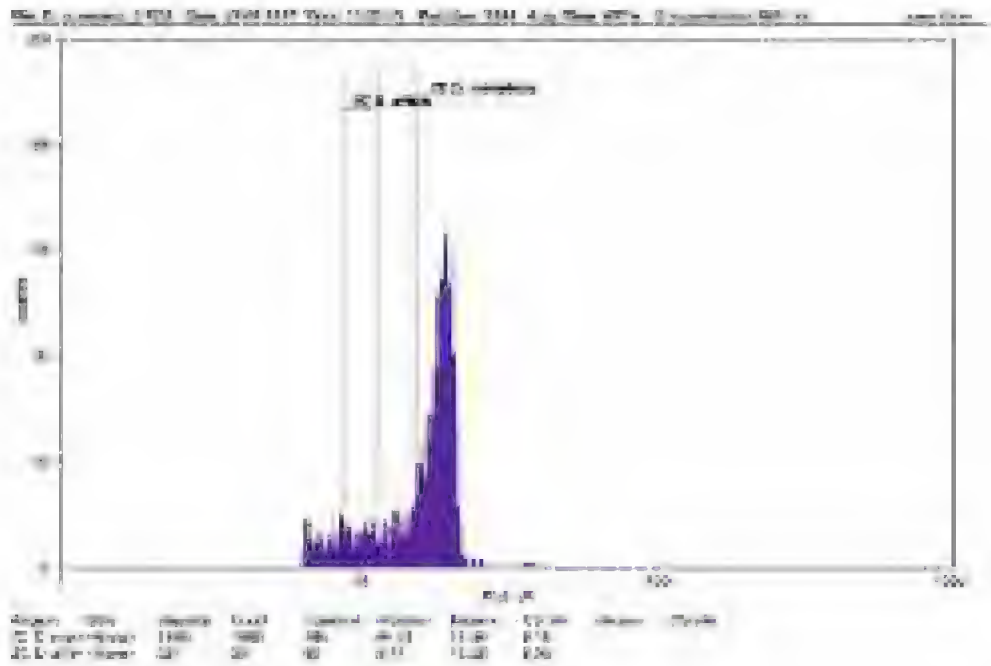
Table 1. Comparison of morphological characters of *Dryopteris affinis* subsp. *jessenii*, *D.* ×*complexa* nothosubsp. *complexa*, *D.* ×*complexa* nothosubsp. *transsilvanica* and *D. filix-mas*.

Character	Dryopteris affinis ssp. jessenii	Dryopteris ×complexa nssp. complexa	Dryopteris ×complexa nssp. transsilvanica	Dryopteris filix-mas
Leaf colour	medium dark green to dark green, matt	light green to dark green, matt	light green to dark green, matt	light green to medium dark green, matt
Spot at the pinna-midrib base (on living specimens)	medium distinct colour, paler towards the tip of the lamina	slightly faint, paler towards the tip of the lamina	slightly faint, paler towards the tip of the lamina	lacking
Pinna-segment (pinnule) shape	straight cut, with strong teeth at the top	rounded, crenate at margins and with few teeth at the top	straight cut to rounded, with strong teeth at the top	rounded, with teeth in the margins and at the top
Colour of scales	black-brown	light to dark brown	light to dark brown with black-brown basis	light to dark brown
Spores	mostly good	mostly shapeless and abortive	mostly shapeless and abortive	mostly good
Ploidy and reproductive mode	diploid apomict; 2n=82	tetraploid semi-sterile (partial apomict); 2n=164	tetraploid semi-sterile (partial apomict); 2n=164	tetraploid sexual; 2n=164

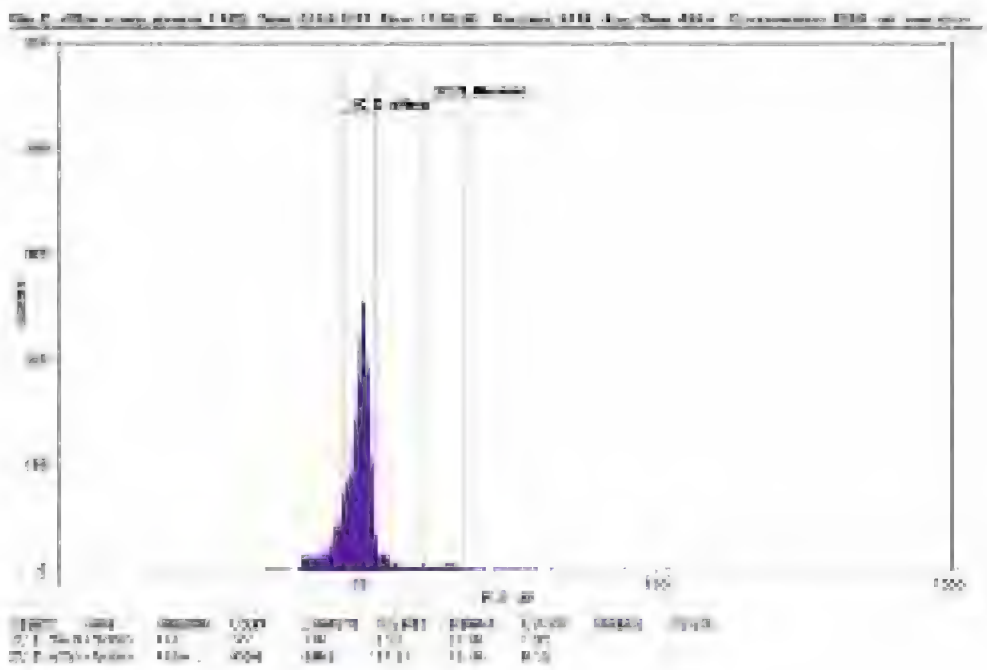
Note: For further differences between subspecies and hybrids see Fraser-Jenkins (2007).



A. Tetraploid *Dryopteris filix-mas*.



B. Tetraploid hybrid *D.* × *complexa* nothosubsp. *transsilvanica*.



C. Diploid *D. affinis* subsp. *jessenii*.

Figure 7. Flow cytometer histograms showing the relative DNA content in leaves.

1996). One locality was recently discovered in Poland, in the Little Beskid Mts. (Hrobacza Meadow; Tlałka, 2015), and more recently in Macedonia, in the Plačkovica Mts. (Laki; Melovski, 2016).

It is highly probable that further localities of the hybrid will be discovered in Romania and Poland, as well as in the neighbouring countries of Slovakia, Ukraine and Hungary, in sites where *Dryopteris affinis* subsp. *jessenii* exists. The range of the hybrid overlaps in the Romanian Carpathians with *D.* ×*complexa* nothosubsp. *complexa*. The ranges of other hybrids of *D.* ×*complexa* are disjunct and include western and southern Europe and western Asia (Jeßen, 1991; Fraser-Jenkins, 2007).

TYPIFICATION AND DESCRIPTION

Dryopteris ×complexa Fraser-Jenk. nothosubsp. transsilvanica Tlałka, S.Jess., A.Rostański & Rojek, nothosubsp. nov. *Dryopteris affinis* (Lowe) Fraser-Jenk. subsp. *jessenii* (Fraser-Jenk.) Fraser-Jenk. × *Dryopteris filix-mas* (L.) Schott

Holotypus: SJ-1310, leg. S. Jeßen 05.08.1985, cult. in Chemnitz, 14.10.2017 (JE).Isotype: SJ-1310, leg. S. Jeßen 05.08.1985, cult. in Chemnitz, 28.06.2016 and 14.10.2017 (Herbarium S. Jeßen). Paratypi: SJ-1303: Romania, Northern Făgăraş, Şerbota valley SSO Porumbacu de Sus, ca. 580 m a.s.l., leg. S. Jeßen 01.08.1985; SJ-1303, cult., 28.06.2016

Locus: first discovered in 1985 in the Romanian Carpathians in the Făgăraş Mountains, then in the Polish Western Carpathians, in the Little Beskid Mountains in 2015. The localities are more than 600 km apart (see Figure 8) Romania, Southern

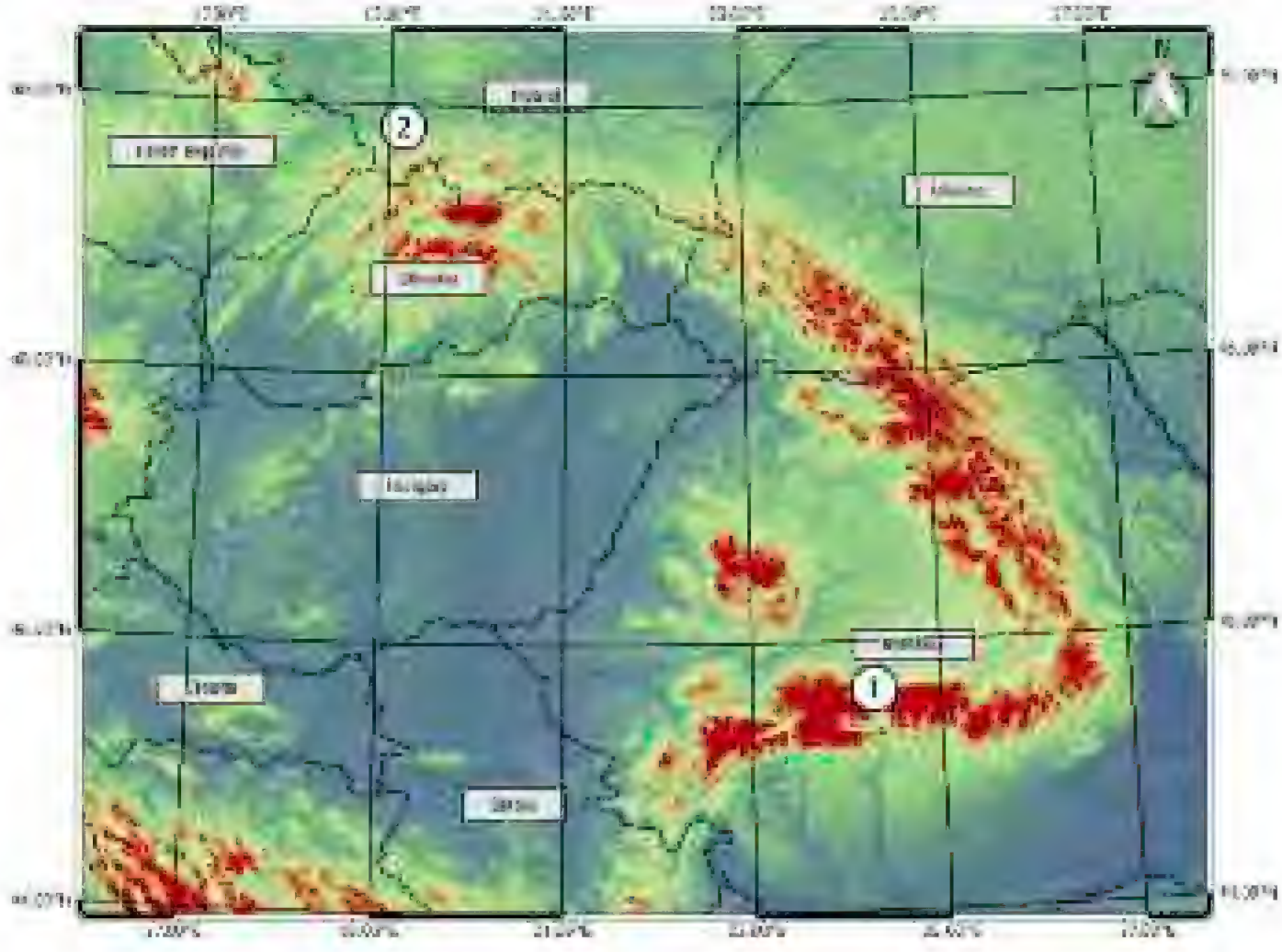


Figure 8. Localities of *Dryopteris* ×*complexa* nothosubsp. *transsilvanica* in the Carpathians.**1:** Romania, Northern Făgăraş Mts., Şerbota valley; **2:** Poland, The Little Beskid Mts., Hrobacza Meadow.

Carpathians, Northern Făgăraş Mountains: Şerbota valley SSO Porumbacu de Sus, c. 750 m a.s.l.

1 – Romania, Southern Carpathians, Northern Făgăraş Mountains, Şerbota valley SSO from Porumbacu de Sus, in the beech forest 2 individuals together with *Dryopteris affinis* subsp. *affinis* var. *disjuncta*, *D. affinis* subsp. *jessenii*, *D. borreri* and *D. filix-mas*: 1. c. 750 m a.s.l., 45.6518°N, 24.5180°E, leg. S. Jeßen 05.08.1985 (SJ-1310), *n*=49-53 II + 58-66 I, tetraploid, det. H. Rasbach 02.09.1987; 2*n*=ca. 164, tetraploid, det. H. Rasbach 29.09.1987 (Jeßen, 1991); 2. c. 580 m a.s.l., 45.6699°N, 24.5145°E, leg. S. Jeßen 01.08.1985 (SJ-1303).

2 – Poland, Silesian Voivodship, Czernichów Commune, Międzybrodzie Bialskie – the Little Żarnówka, the Little Beskid, Hrobacza Meadow, E slope, 580-620 m a.s.l., in the beech forest 2 individuals together with *Dryopteris affinis* subsp. *jessenii*, *D. borreri*, *D. cambrensis* subsp. *insubrica*, *D.* × *convoluta* nothosubsp. *convoluta* and *D. filix-mas,* 49.8216°N, 19.1752°E and 49.8215°N, 19.1731°E, leg. D. Tlałka 2015; 2*n*=164, tetraploid.

Derivation: After the place of discovery, the Southern Carpathians, which are also called "Transylvanian Alps".

Descriptio:

Planta hybrida, media inter parentes, scilicet *Dryopteris affinis* subsp. *jessenii* et *Dryopteris filix-mas*; frondes usque ad 120 cm, rarius ad 140 cm longae; lamina pinnata ad bipinnata, pinnae longissimae evidenter 1–3 mm stipitatae, petioli pinnarum maculati violacei; pinnulae saepe ut in parallelogrammi formatae, in apice truncatae aut rotundatae cum dentibus robustis, acutis; sporae abortivae; planta tetraploidea, chromosomatum numerus = 164, meiosi bivalentibus 49–53, univalentibus 58–66.

Description:

Rhizome single, in older plants multi-headed, with ± funnel-shaped fronds; Leaf-blade mostly dull, dark green, lanceolate to broadly lanceolate, much narrowed towards the base, glandless, up to 120 (–140) cm long and up to 25 (–35) cm wide; Petiole 1/4–1/3 of the frond length; Scales on petiole to about 20 × 5 mm, ± glossy, light to dark brown, often with a chestnut to black-brown zone at the base; Scales on mid rachis narrow, oval-lanceolate, often chestnut to dark brown towards base; Scales of the pinnae narrow-oval to lanceolate, mostly light brown; Basiscopic pinnae short, up to c. 7 × 3 cm; clearly stalked 2–3 mm; lowest basiscopic pinnule equal or not much longer than the acroscopic pinnule opposite, inner side with 1–2 lobes, tip with truncated end and strong, pointed teeth directed apically; Medium pinnae petiolate 1–3 mm, up to 17 cm × 2–3 cm with 20–30 pinnule pairs; pinnae bright green, rarely 1–3 mm in length, partly dark purple; Pinnule segments of the middle pinnae crowded, the base almost pedunculate, partially covering the rachis; up to about 15 × 5 mm, 2–3 times longer than wide, broadly sessile, slightly narrowed at the top or narrowly rectangular (up to almost rhombic), slightly lobed or serrated at the edge, at the end mostly rounded, rarely a little trimmed, with strong, pointed teeth directed apically; Sori 1.3–1.6 mm in diameter; Indusium in the immature sorus hemispherical, arched, partly with margin turned outwards, shrinking after spore maturation, but mostly lasting, sometimes tearing from the margin, glandless; Usually 50–80 % failed sporangia, these whitish or yellowish and releasing no spores; Spores >90 % aborted, heterogeneous in size and shape, crumbly, black-brown to brown, occasionally large, spherical; Guard cell length 61.9 ± 5 µm. Cytology: $n = 2n = 164$, tetraploid, spores irregular; $n = 49–53$ bivalent and 58–66 univalent (Jeßen, 1991).

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MEIOTIC CHROMOSOME BEHAVIOUR OF APOGAMOUSLY PRODUCED HAPLOID SPOROPHYTES IN *WOODWARDIA ORIENTALIS* AND *W. PROLIFERA*

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Key words: autotetraploid, dihaploid, haploid, meiosis, *Woodwardia orientalis, Woodwardia prolifera*

ABSTRACT

Sporogenesis of dihaploid *Woodwardia orientalis* with 2n=68 and haploid *W. prolifera* with 2n=34 produced by induced apogamy was investigated. The meiotic chromosome behaviour in spore mother cells of dihaploid *W. orientalis* showed many bivalent chromosomes, while that of haploid *W. prolifera* showed 34 univalent chromosomes at metaphase I. These observations support a basic chromosome number of x=34 for *Woodwardia*, with *W. orientalis* being an autotetraploid (2n=4x=136) and *W. prolifera* a diploid (2n=2x=68). Guard cell sizes of both induced haploid sporophytes were smaller than those their parental sporophytes ($t<0.01$).

INTRODUCTION

Following the development of a method to induce apogamy in gametophytes by sterile culture on a nutrient medium containing sugar, apogamous sporophyte formation in eight species has been induced (Whittier & Steeves, 1960; 1962), and apogamous sporophyte formation in 15 fern species has been induced by using sugar and hormones (Kawakami et al., 1995; 1996; 1997). These apogamously produced plants have half the chromosome number of the parental sporophyte – haploids being derived from a diploid species, or dihaploids from a tetraploid.

Polyploidy and high basic chromosome number are characteristic cytological features in ferns (Walker, 1979). The apogamously produced haploid plants from tetraploids are useful material for cytological study to uncover the origins of the tetraploid sporophytes through observation of meiotic chromosome behaviour in spore mother cells. Bivalent chromosomes support an autotetraploid origin, whereas mostly univalent chromosomes support an allotetraploid origin. Such observations have been reported in several induced apomict ferns (Manton, 1950; Manton & Walker, 1954; Bouhamont, 1972; Palta & Mehra, 1983; Kawakami et al., 1995; 1996).

The chromosome number of *Woodwardia orientalis* Sw. was determined to be n=68 (Mitui, 1967; 1968; Tsai & Shieh, 1983) and 2n=136 (Takamiya et al., 1992). The chromosome number of *W. prolifera* Hook. et Arn. was determined to be n=34 (Mitui, 1967; 1968; Tsai & Shieh, 1983) and 2n=68 (Takamiya et al., 1992). *Woodwardia orientalis* with 2n=136 has been recognised to be the only tetraploid in the genus *Woodwardia* (Takamiya et al., 1992); *W. prolifera* is diploid with 2n=68 (Takamiya et al., 1992), but was at one time treated as a subspecies of *W. orientalis* (*W. orientalis* var. *formosana* Rosent.) because of the very close external morphological resemblances with *W. orientalis* (Iwatsuki, 1992), but it has been proposed that *W. orientalis* (2n=4x=136) might be autotetraploid derived from *W. prolifera* (2n=68) as a result of chromosome doubling (Mitui, 1968). However, karyomorphological studies support the view that *W. orientalis* is an allotetraploid, derived by chromosome doubling from a hybrid of *W. prolifera* and an unknown diploid (Takamiya et al., 1992).

To help clarify the origin of *W. orientalis*, meiotic behaviour in spore mother cells of induced apomicts from *W. orientalis* and *W. prolifera* have been studied, and the relative DNA contents and guard cell sizes compared the apomicts and the parental sporophytes.

MATERIALS AND METHODS

Woodwardia orientalis was collected from Ishinomaki, Toyohashi City, Aichi Pref. and *W. prolifera* was a gift from the Higashiyama Botanical Gardens, Nagoya City, Aichi pref. The induced apomicts from *W. orientalis* and *W. prolifera* were developed by Kawakami et al. (1997). They have been cultivated for more than 10 years. Sporangia were fixed in 3:1 ethanol-acetic acid for 30 min at 5°C and squashed in 2% aceto-orcein solution. DNA content of nuclei in fronds was estimated by flow-cytometry using a Partec Ploidy Analyzer PA (Partec Münster, Germany) (Kawakami et al., 2003).

RESULTS

The fronds of the apomicts were smaller than those of the parental sporophytes, but otherwise were similar in morphology (Figure 1). The sprouting fronds were tinged in red in both in the haploid and the parental plant of *W. prolifera* while those of *W. orientalis* were green.

Comparison of guard cell size is shown in Figure 2. The mean size of 100 guard cells was 54.0 μm in normal *W. orientalis* and 40.2 μm in the corresponding dihaploid, 45.5 μm in normal *W. prolifera* and 31.7 μm in the haploid. Guard cells of apogamously produced sporophytes were significantly smaller in *W. prolifera* and in *W. orientalis* ($t<0.01$). Chromosome counts were confirmed for the parental plants of *W. orientalis* (68 bivalents, 2n=136) and *W. prolifera* (34 bivalents, 2n=68) (Figure 3).

Sporogenesis of dihaploid *W. orientalis* (2n=68) showed (Figure 4) many bivalents and some univalents at metaphase I (Figure 4B). Rarely 34 bivalents were observed (Figure 4C). Lagging chromosomes were seen frequently at anaphase I. Two nuclei were formed in the first division (Figure 4D) and tetrad spores with some abnormal spores were produced after the second division (Figure 4E). In most sporangia young spores were observed (Figure 4F), but at a later stage spores collected from fronds were mostly sterile. Eight out of approximately 1000 spores showed an ability to germinate.

Sporogenesis of haploid *W. prolifera* (Figure 5) showed only 34 univalents at metaphase I (Figure 5B). Occasionally two nuclei of different sizes (Figure 5C) or three nuclei (Figure 5D) were observed. A few tetrads with irregular shapes were found (Figure 5E), but no spores developed in the sporangia (Figure 5F).

DNA content of nuclei is given in Figure 6. Dihaploid *W. orientalis* showed approximately half that of the parental tetraploid (Figure 6A) and haploid *W. prolifera* showed approximately the half of that of the diploid (Figure 6B).

DISCUSSION

The relationship between guard cell size and polyploidy has been demonstrated in ferns (e.g. Takahashi, 1962; Kawakami et al., 2007; Kawakami et al., 2017). In the present study the size of guard cells shows a significant reduction in both induced apogamous plants.

For *Woodwardia orientalis* both an autotetraploid origin from *W. prolifera* (Mitui, 1968), and an allotetraploid origin from *W. orientalis* and another diploid taxon, based on karyomorphology (Takamiya et al.,1992), have been proposed. The observations of many (up to 34) bivalents in the spore mother cells of the apogamously produced diploid sporophyte in the present study supports the view that *W. orientalis* is autotetraploid.

For polyploid sporophyte formation in ferns it is considered that unreduced spores play very important role in nature (Gastony 1986). Autotetraploid *W. orientalis* (2n=136), therefore, might be produced by fertilization of 2x gametes derived from unreduced spores produced in the diploid *W. orientalis* (2n=68). Since it is known that unreduced spores are produced in haploid, triploid and hybrid sporophytes in which homologous chromosome pairing is failed at meiosis, in the case of diploid *W. orientalis*, unreduced

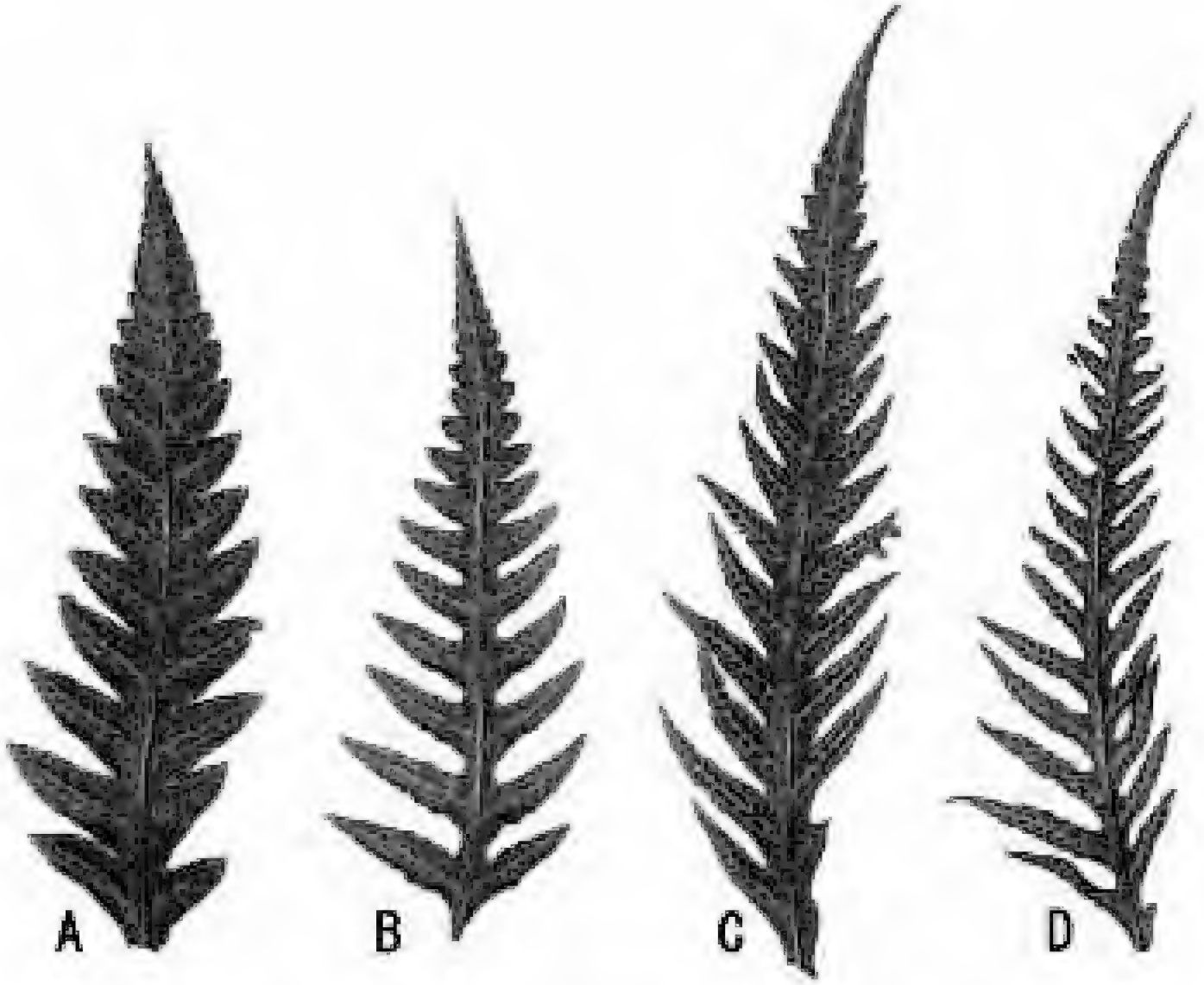

Figure 1. Fronds of *Woodwardia orientalis* and *W. prolifera*. A: Tetraploid *W. orientalis* (2n=136); B: Dihaploid *W. orientalis* (2n=68); C: Diploid *W. prolifera* (2n=68); D: Haploid *W. prolifera* (2n=34).

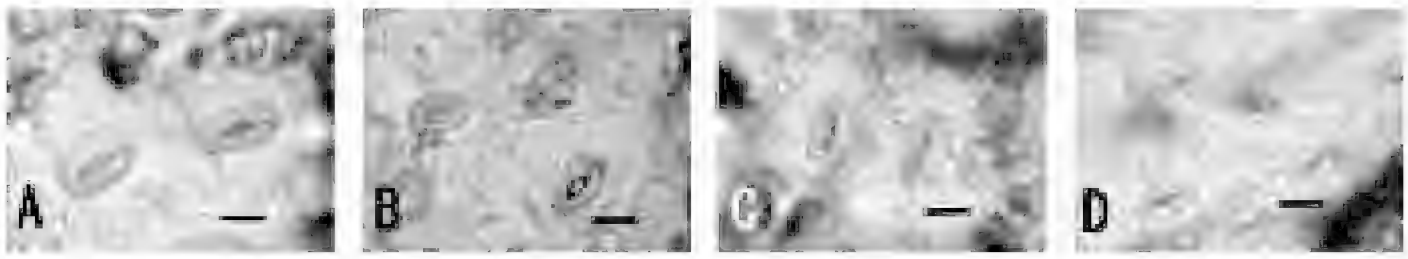

Figure 2. Guard cells of *Woodwardia orientalis* and *W. prolifera*. A: Tetraploid *W. orientalis* (2n=136); B: Dihaploid *W. orientalis* (2n=68); C: Diploid *W. prolifera* (2n=68); D: Haploid *W. prolifera* (2n=34). Scale bars; 25 μm.

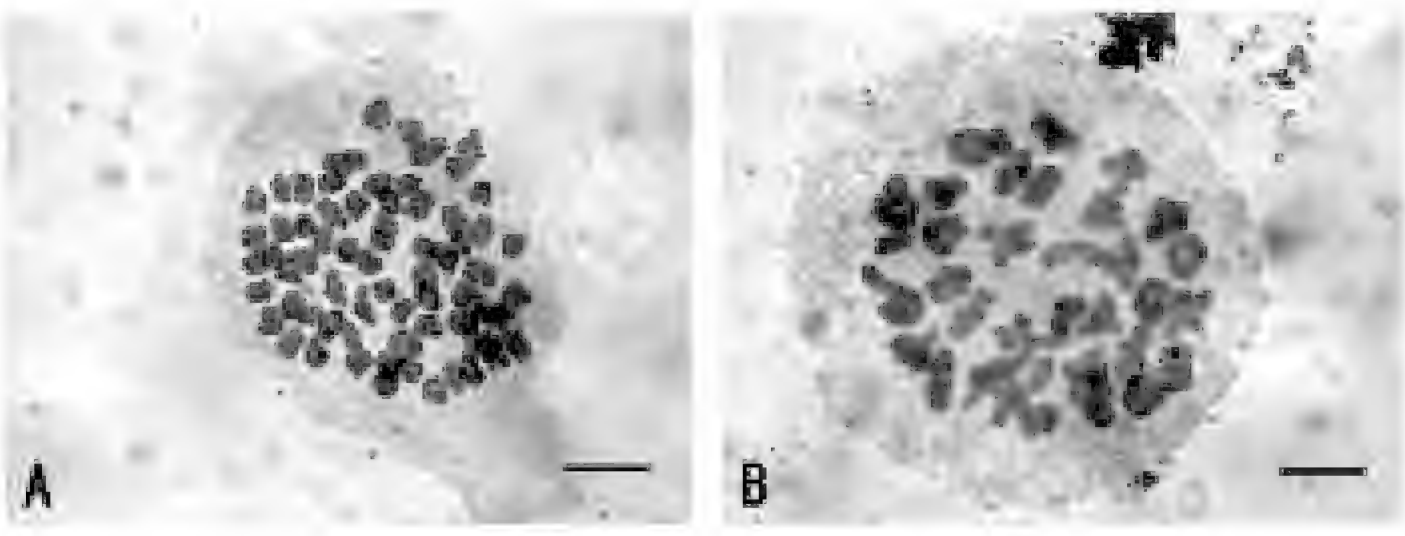

Figure 3. Meiotic chromosomes in *Woodwardia orientalis* and *W. prolifera*. A: Tetraploid *W. orientalis* showing 68 bivalents; B: Diploid *W. prolifera* showing 34 bivalents. Scale bars; 10 μm.

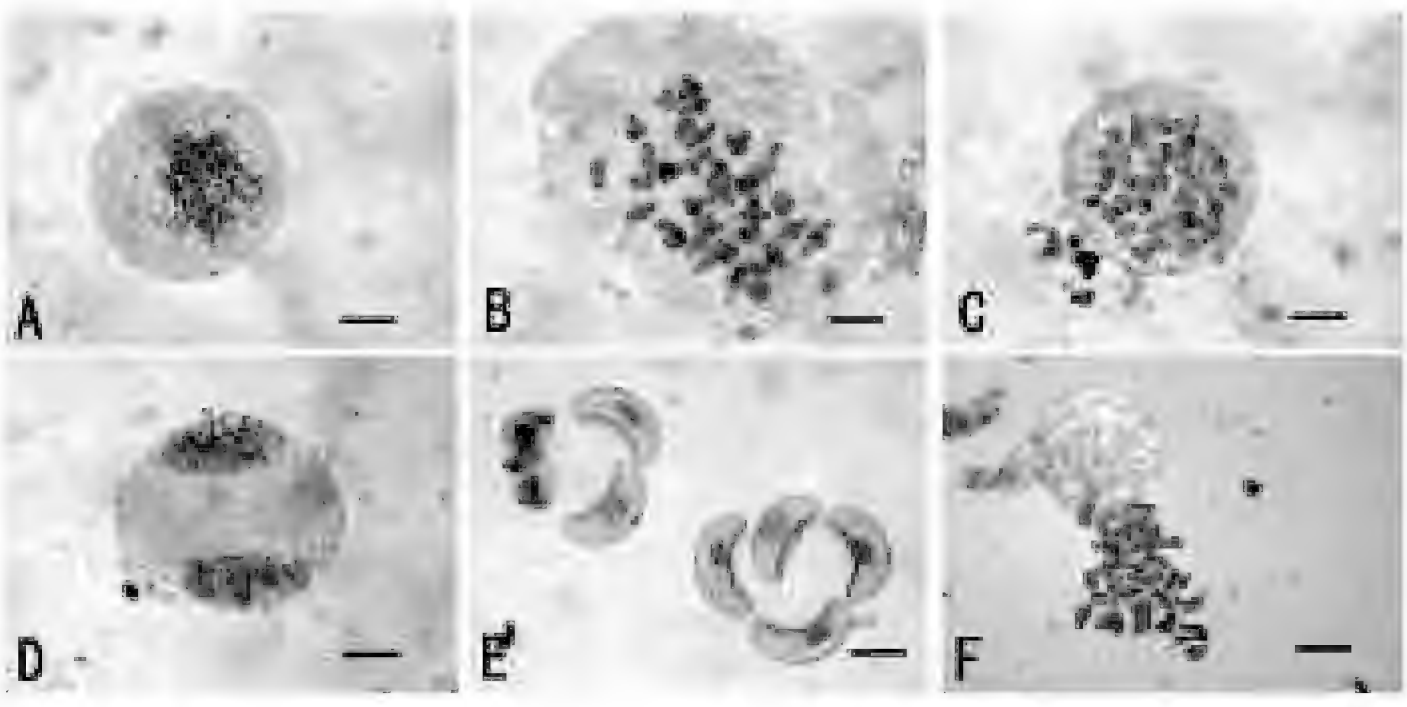

Figure 4. Sporogenesis in dihaploid *Woodwardia orientalis* (2n=68). A: prophase; B: meiotic chromosomes with many bivalents and a few univalents; C: meiotic chromosomes with 34 bivalents; D: two nuclei formed by the first division; E: tetrads with normal and abnormal spores; F: spores from one sporangium. Scale bars: A,B,C,D: 10 μm; E: 25 μm; F: 100 μm.

spores might be produced in diploid *W. orientalis* with some chromosome variation that was occurred accidentally by some means. This conflicts with the evidence based on karyomorphology (Takamiya et al., 1992), that gives a karyotype of 2n=136=8m+24sm+104(st+t), but, on morphology, does not have four homologous chromosome sets. However, differentiation within the karyotype does not appear to have been sufficient to prevent the ability of full pairing (34 bivalents) in the dihaploid. The evidence presented here does support an autotetraploid origin of *W. orientalis*, but does not clarify whether the parental diploid of *W. orientalis* was *W. prolifera*.

The evidence that 34 univalents were observed at metaphase I in haploid *W. prolifera* confirms the basic chromosome number of *Woodwardia* as x=34.

In our previous studies, meiotic chromosome behaviour of haploid sporophytes

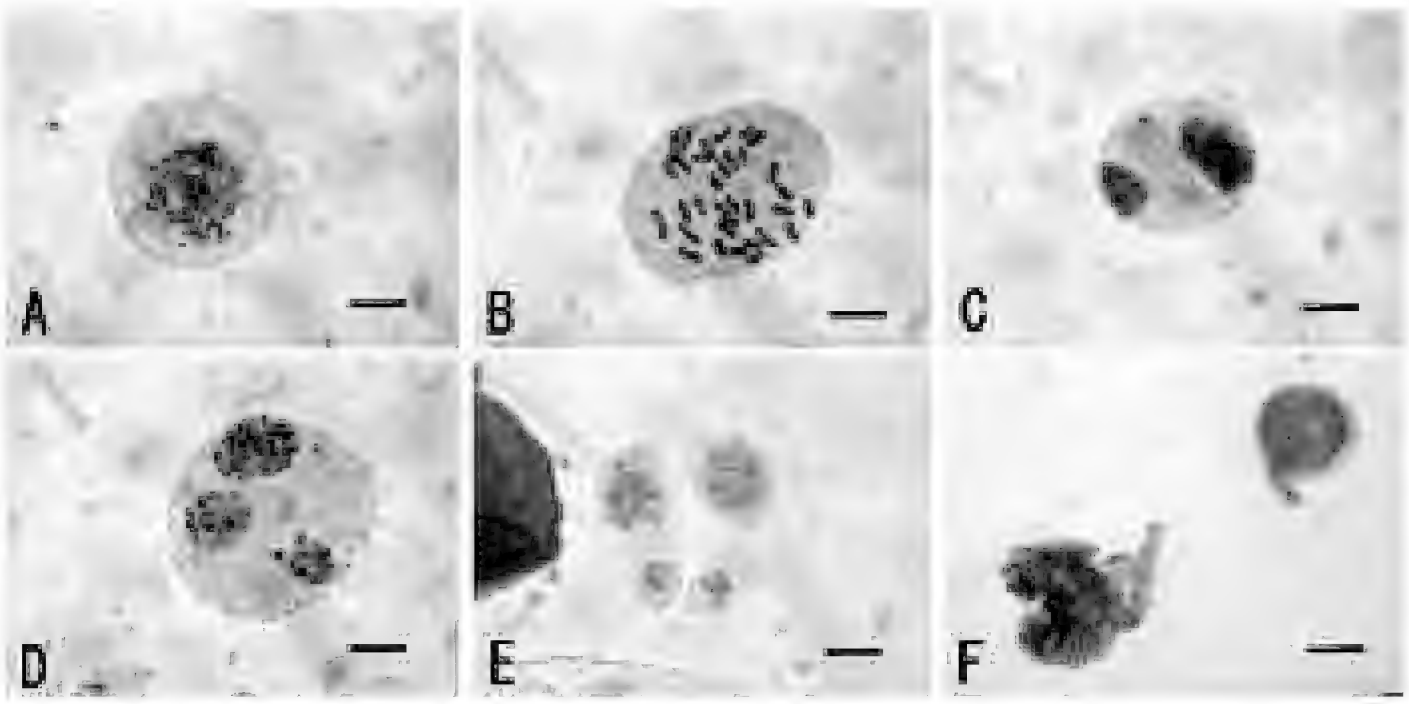

Figure 5. Sporogenesis in haploid *W. prolifera* (2n=34). A: prophase; B: meiotic chromosomes with only 34 univalents; C: two nuclei of different sizes; D: three nuclei of different sizes; E: a tetrad with irregularly sized spores; F: sporangia with no spores. Scale bars: A,B,C,D,E: 10 μm; F: 100 μm.

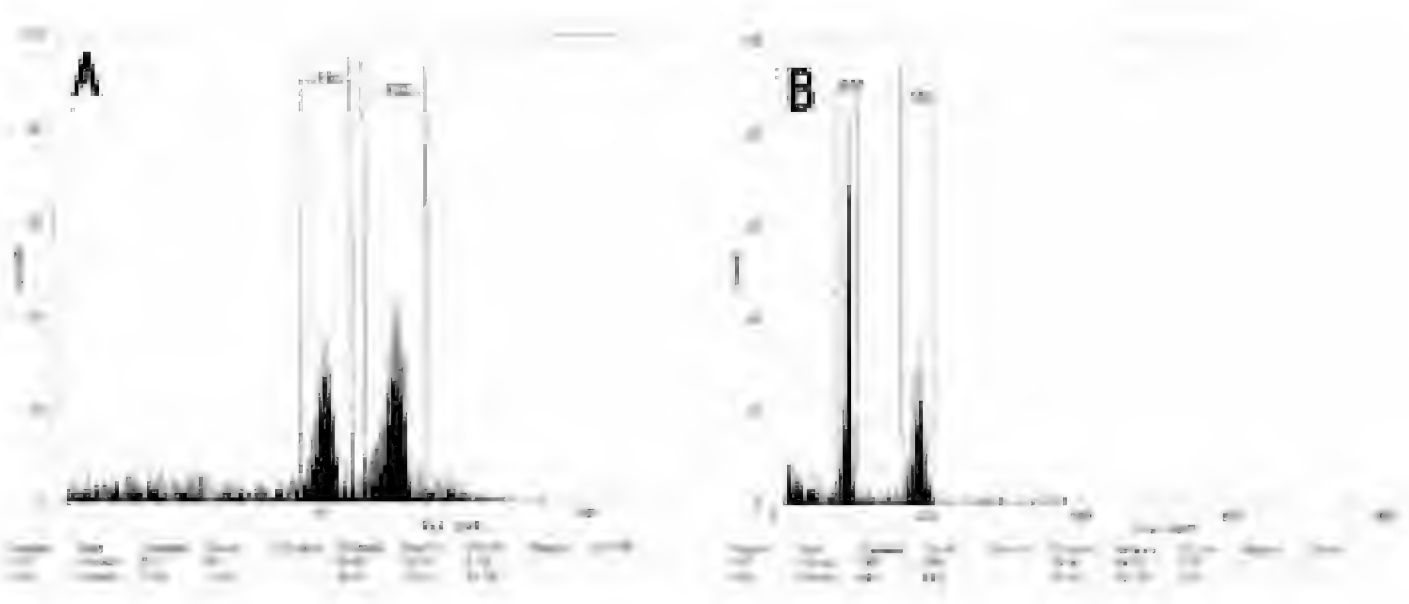

Figure 6. Relative DNA contents of nuclei of sporophytes. A: *Woodwardia orientalis* with 2n=68 (PK1) and with 2n=136 (PK2). B: *Woodwardia prolifera* with 2n=34 (PK1) and with 2n=68 (PK2).

produced by induced apogamy has been observed in four fern species: dihaploid *Pteris dispar* Kze. (2n=2x=58) with many bivalents (maximum 29) produced fertile reduced spores (Kawakami et al., 1996); dihaploid *Pteris multifida* Poir (2n=2x=58) showed a few bivalent chromosomes, and dihaploid *Pteris semipinnata* L. (2n=2x=58) showed only 58 univalent chromosomes but neither produced fertile reduced spores (Kawakami et al., 1995; Kawakami et al., 1996). The few fertile spores produced in dihaploid *W. orientalis* in the present study might be reduced spores, if the 34 bivalents at metaphase I can occasionally give balanced segregation, or by restitution before or during meiosis. Haploid *W. prolifera* with 34 univalents at metaphase I did not produce any fertile spores. Another induced haploid, *Osmunda japonica* (2n=x=22) with 22 univalents produced many fertile unreduced spores, presumably as a result of restitution (Kawakami et al., 2003).

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BOOK REVIEW

An annotated checklist of Indian Pteridophytes, Part 2. Fraser-Jenkins, C.R., Gandhi, K.N. & Kholia, B.S. 2018. pp 574. Bishen Singh Mahendra Pal Singh, Dehra Dun, India. Price Indian Rs 5850.00, US $ 100.00, £80.00, Euro 95.00.

A review of *An annotated checklist of Indian Pteridophytes, Part 1* was published in 2016 in The Fern Gazette, Vol. 20, Part 3. This second volume follows the same format, but covers the families Woodsiaceae to Dryopteridaceae, and includes some of the larger complex genera like *Dryopteris*, but extensive morphological studies by the first author in the field and herbarium, coupled with cytological investigation, has already helped resolve some of the difficulties arising from extensive hybridization and polyploidy in the genus.

The volume comprises chapters on classification, the taxonomic treatements of the four families Woodsiaceae, Onocleaceae, Blechnaceae and Dryopteridaceae, a long appendix with corrections and additions to Part 1, and 356 colour photographs. A list of references is provided at the end of each family account and Part 2 concludes with a taxonomically arranged index of accepted and excluded taxa.

An annotated checklist of Indian Pteridophytes, Part 2 starts with a discussion of classification, as a consensus classification based on molecular data by the Pteridophyte Phylogeny Group (PPG-1) (2016), was published shortly after the publication of *Part 1*. This scheme is heavily criticised, particularly for the break-up of genera like *Lycopodium*, *Marattia*, *Osmunda*, *Asplenium* and *Blechnum* based on "minor and insignificant characters", and "should be more appropriately recognised as infra-generic sections". But the value of molecular data is not rejected outright, and the classification published by Smith, Pryer, Schuettpelz, Korall, Schneider & Wolf (2006) based on morphological and molecular evidence is recognised as "largely taxonomically stable, practical and comprehensible". However, an appendix to *Part 2* was added after the publication of nomenclatural changes by Christenhusz, Fay and Bing (2018) that resulted in 3286 new combinations – "approximately 1000 in Pteridophytes"; this publication is heavily criticised, and a long list of these new combinations are synonomised back to their earlier genera and species names. The classification used in *Part 2* is that given in full in *Part 1*.

Most of the volume is given up to the very detailed checklist, each taxon with the type material given (and lectotypes designated where required), and extensive synonomy, followed by distribution in India and elsewhere. The authors also include discussion of a number of 'excluded' species - those taxa that have been erroneously reported for India. Further notes may cover discussion of disputed records, previous taxonomic treatments, interpretation of herbarium labels, and morphological variation between populations and it is made clear where further detailed work is required. For example for the genus *Cyrtomium*, the authors avoid listing any Chinese synonyms as they feel that much more detailed morphological and cytological work is needed to clarify many of the species names used in the account in *Flora of China* (Wu et al., 2013).

Other little nuggets are included – *Tectaria coadunata* (C.Presl) Copel. "is the 'kalo neuro' [black fern] of nutritional and medicinal use…in Nepal". *Diplazium maximum* (D.Don) C.Chr. is the correct name for the "common large and edible species of the whole Himalayan region …. long known in the West Indo-Himalaya as "*D. polypodiodes*" in error, …. but *D. polypodiodes* is a quite different Malesian species…

.. and in India is confined to the South".

Twenty-nine new taxa are described, and usefully listed in **bold** in the index.

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MARY GIBBY

INSTRUCTIONS FOR AUTHORS

PAPERS should not usually exceed 20 printed pages and are generally expected to be considerably shorter. As well as reports of original research, review articles and short notes, e.g. new records, are encouraged. The senior author should supply an email address to facilitate correspondence.
REVIEWS should cover recent developments in any aspect of research on ferns and lycopods. This can include unpublished research by the author, and/or the possible direction of future research. They should be aimed at the general reader who may not be an expert in the chosen topic. Proposals for a review should be discussed first with the review editors.
MANUSCRIPTS should be submitted in English (British) in electronic format in 10-point Times New Roman font and double spaced. Electronic versions of text and tables should be compatible with WORD, with figures as pdf or jpg files, and sent as email attachments or CDroms. All manuscripts will be refereed.
THE TITLE should reflect the content of the paper and be in BOLD CAPITALS (11-point) and centrally aligned. Generic and specific names should be in italics and any title containing a generic or specific name should be followed by the family name in brackets e.g.

***TRICHOMANES SPECIOSUM* (HYMENOPHYLLACEAE) IN SOUTHERN SPAIN**

AUTHOR ABBREVIATIONS should follow Pichi Sermolli's (1996) Authors of scientific names in Pteridophyta, Royal Botanic Gardens, Kew.
MAIN HEADINGS: should be in **BOLD CAPITALS** (10-point) and centrally aligned.
SUBSIDIARY HEADINGS: should be in **bold**, the first letter of each word in capitals, the rest in lower case and left-aligned.
AUTHORS' NAMES AND FULL ADDRESSES (including email address): follow the title and are centrally aligned.
KEY WORDS: up to ten.
ABSTRACT: should reflect the content of the paper.
FIGURES: there is no distinction between photographs and line drawings in numbering. All should be presented in a form ready for reproduction, colour, TIF format and 300 dpi (please contact editor with queries), with a scale bar where appropriate. Lettering or numbers (Arabic) should be in the bottom left using uppercase Times Roman. Figure captions should be on a separate sheet.
TECHNICAL INSTRUCTIONS: these can be found at:
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CHECKLISTS: follow the format of Baksh-Comeau, Fern Gaz. 16 (1, 2): 11- 122.
REFERENCES: follow the style of a recent issue of The Fern Gazette, e.g.:-
HOOKER, W.J. 1864. Species Filicum, 5. Dulau & Co., London.
MORTON, C.V. 1947. The American species of *Hymenophyllum*, section *Sphaeroconium*. Contr. U.S. Natl. Herb. 29(3): 139-201.
STEVENSON, D.W. & LOCONTE, H. 1996. Ordinal and familial relationships of pteridophyte genera. In: CAMUS, J.M., GIBBY, M. & JOHNS, R.J. (Eds) Pteridology in perspective, pp. 435-467. Royal Botanic Gardens, Kew.
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REVIEW
EDIBLE FERNS AND LYCOPHYTES IN ASIA

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Keywords: ethnobotany, ethnopteridology, food, pteridophyte, starch, tea, vegetable, wine

ABSTRACT

This review aims to enhance awareness of edible ferns and lycophytes in Asia. After searching the literature and relevant websites, a summary is presented of 172 taxa belonging to 61 genera and 29 families, in 14 Asian countries or regions. Dietary usage of those ferns can be classified into four main categories, i.e., vegetables, starch suppliers, beverages and snacks, of which use as a vegetable is the most frequent (144 taxa, 68%). Their leaves, especially young and tender ones, are the most frequently used organs for food. In Asia, *Diplazium esculentum* and *Blechnopsis orientalis* probably are the two most popular vegetables among ferns and lycophytes. About 16% of the taxa of edible ferns are used as starch suppliers. The massive rhizomes (stems) of tree ferns and species of the genera *Coniogramme*, *Drynaria*, *Angiopteris* and *Pteridium*, usually have abundant starch and hence are often extracted to prepare cakes, noodles, or even to produce alcohol. Beverages (ca. 12% of edible ferns) include herbal tea and liquor. Herbal tea, which is a favourite for many Asian people, is often made from a mixture of several kinds of ferns or with other vascular plants. Fern liquor may be made from starch of rhizomes or leaves. The other usages (ca. 4% of edible ferns), such as snacks and as a substitute for baking soda, are recorded from different aboriginal tribes. This review is intended to give a general overview of edible ferns in Asia as a basis for further extensive and in-depth studies.

INTRODUCTION

About 11,916 species of ferns (monilophytes) and lycophytes (herein together referred to as pteridophytes or simply as ferns) are distributed around the earth (PPG I, 2016), and the fern flora of Asia ranks amongst the world's richest. For example, some 4,400 pteridophyte species (ca. 40% of the world total) are known from South-East Asia (de Winter & Amoroso, 2003). Wild edible ferns are frequently utilized for food by Asian people, especially amongst the aboriginal tribes. Almost all ethnic people have been using ferns as a source for food since time immemorial (Handique, 2003). The history of eating ferns in China may go back as far as 3000 years; edible ferns such as *Pteridium aquilinum* (L.) Kuhn var. *latiusculum* (Desv.) Underw. ex A.Heller were first mentioned in "Shi-Jing" (Book of Odes) (Zhang, 2007; Liu et al., 2012). Even now, indigenous people of different countries and tribes still collect various ferns for supplementing diets or as substitutes for staple food. Local people, especially those from ethnic minorities in rural areas or remote mountains, have preserved their tradition of harvesting and consuming ferns for generations (Liu et al., 2012). Ferns are not only eaten commonly in developing countries, but also in many developed countries. Edible ferns and their

related products can be purchased in local markets or even supermarkets in Asia.

This review is based mainly on literature research including internet sources. Scientific names are shown together with their current updated taxonomy in Table 1. To give a general profile of the utilization of Asian edible ferns, we summarized their uses into four categories: vegetables, snacks, starch suppliers, and beverages (including herbal tea and liquor). In this article, we aim to present an overall panorama of edible ferns in Asia. Because the literature about this issue is so widespread, we may have not been able to discover all references, but we hope that this review article will depict a valid picture of the variety of edible fern species in different Asian countries and their usage, and promote further extensive exploration and in-depth studies.

NUMBER AND DISTRIBUTION OF EDIBLE FERNS IN ASIA

This survey of the edible ferns recorded in Asia includes a total of 172 taxa (including species, infraspecies and unidentified taxa), belonging to 29 families (26 monilophytes and three lycophytes) and 61 genera. Most edible fern species were in the families of Athyriaceae (38 taxa, 22.1%), followed by Pteridaceae (25 taxa, 14.5%), Dryopteridaceae (12 taxa, 7.0%) and Polypodiaceae (12 taxa, 7.0%) (Figure 1). Among genera, most belonged to *Diplazium* (21 taxa, 12.2%), followed by *Athyrium* and *Coniogramme* (11 taxa and 6.4% for each), *Dryopteris*, *Angiopteris,* and *Pteris* (seven taxa and 4.1% for each) (Figure 2).

Although we have put significant effort in the search of relevant references to cover the entire continent, recorded edible ferns were found only in the Malesian region and 13 Asian countries, of which China had the most (73 taxa), followed by India (55 taxa) and Taiwan (39 taxa) (Figure 3). However, the recorded number of fern species used for food in Asia must be a considerable underestimate. For example, 73 traditionally used edible species are included in this review, but at least 144 fern species in China are inferred to be potentially edible (Liu et al., 2012). Such low estimates may be attributed to lack of detailed, cautious investigation, taxonomic problems (such as taxonomic uncertainty and insufficiency of taxonomic knowledge), incomplete records of related literature sources, and some word-of-mouth communication of distant cultural heritage. Furthermore, some locations were expressed in broad biogeographical terms, e.g., Malesian region (de Winter & Amoroso, 2003). In this case, we refer to other literature to narrow down the location to country or we present it as Malesia only (MR in Table 1). This may also result in the low numbers of records shown for the countries in those regions, e.g., Indonesia, Malaysia and the Philippines. The numbers of edible ferns shown are also likely to be related to the regional fern diversity and the amount of research in each country. In many other Asian countries (ca. 40), to our knowledge there have not yet been any studies of edible ferns.

USAGES OF EDIBLE FERNS

All parts of fern individuals, such as leaves, rhizomes (commonly called stems or tubers in some cases), adventitious buds, stipules, or fleshy roots, are potentially used for food if palatable and nontoxic. Asian people have developed a varied fern cuisine and many related products. Among them, edible ferns are used mostly as a vegetable (69%), followed by a source of starch (15%) and as a beverage (11%). They are also used in other ways, including as a snack (Figure 4). The use as a side dish recorded in some accounts is categorized under ‘vegetable’ in this study.

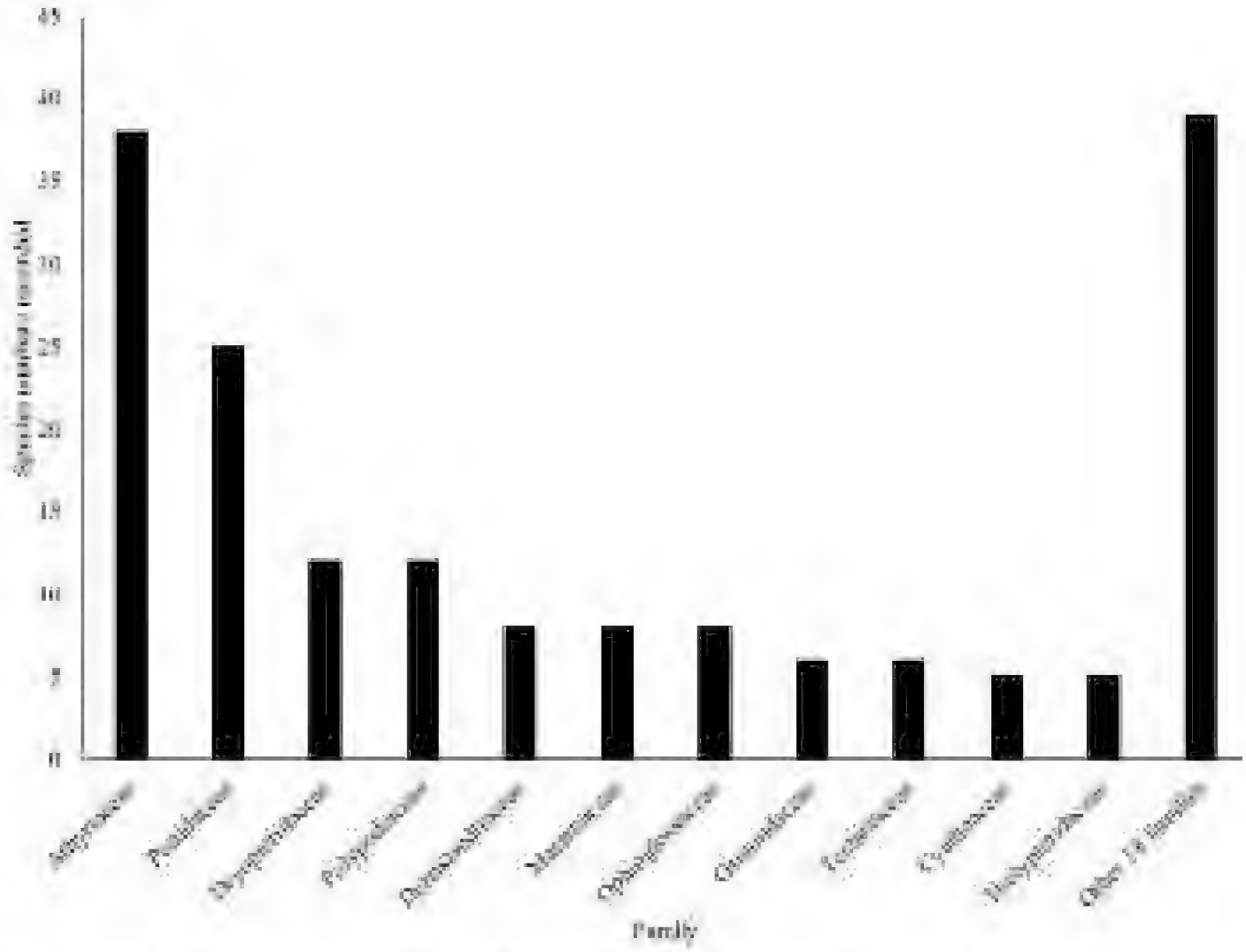

Figure 1. Species number recorded of edible ferns in different families in Asia.

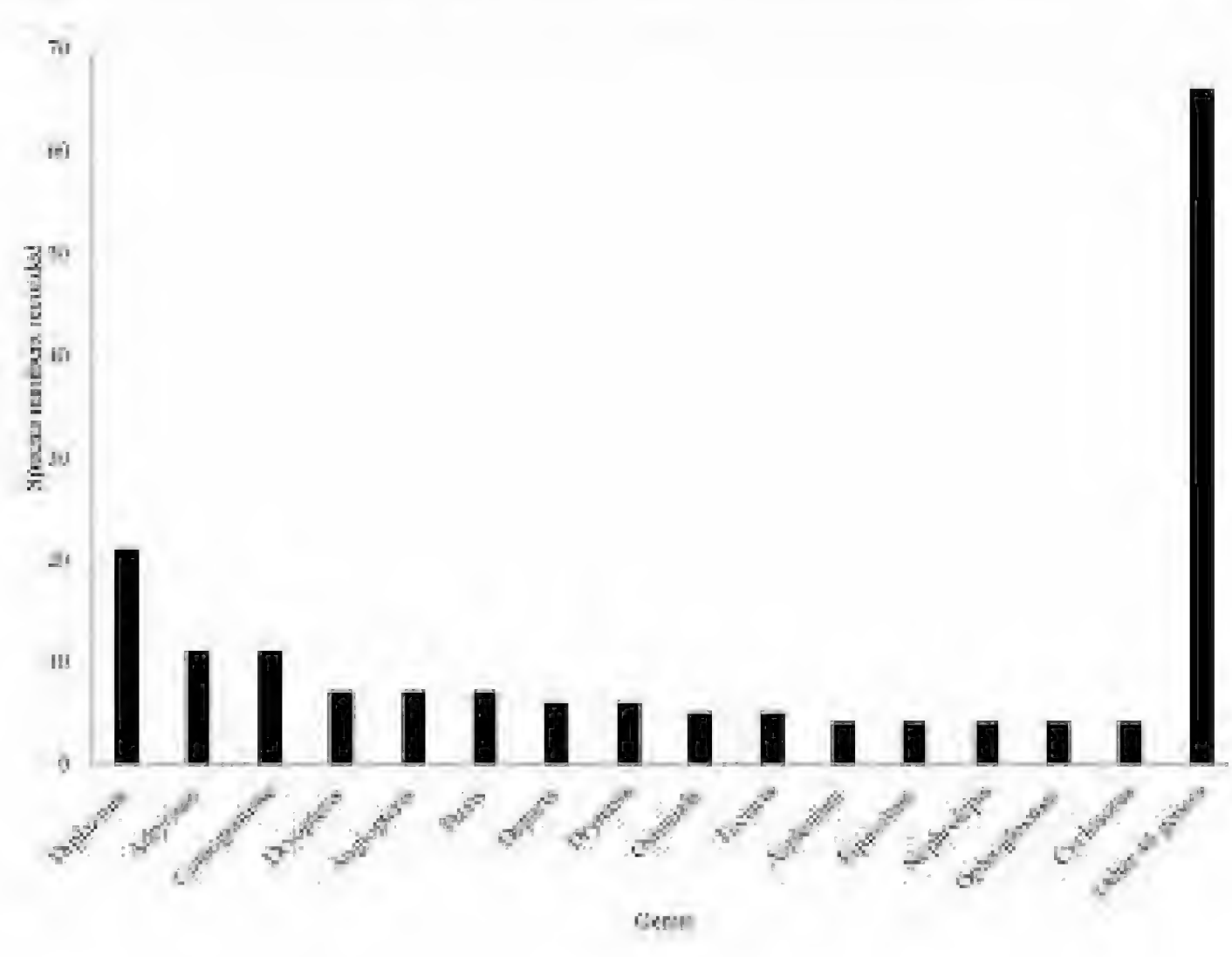

Figure 2. Species number recorded of edible ferns in different genera in Asia.

VEGETABLES

Young, tender, coiled (fiddlehead) and slightly uncoiled leaves are the parts most used as a fern vegetable (Figure 5A, B). The most common vegetable dish is prepared by stir-frying fresh or dry young leaves/shoots (de Winter & Amoroso, 2003; Liu et al., 2012; Huang et al., 2018). Vegetable salad and soup from ferns are also popular (Yumkham et al., 2016). Some species, e.g., *Drynaria coronans* (Wall. ex Mett.) J. Sm. ex T.Moore (rhizomes), are served as a side dish. Fern vegetable dishes may be prepared from young leaves only or, more commonly, mixed with other accessories, such as meat, small dried fish, and/or spices, to improve the taste (Figure 5C, D).

Some wild edible ferns are bitter and not tasty, and treatments of salting, e.g., *Diplazium viridissimum* Christ (Yun et al., 2009), or pickling, e.g., *Pteris wallichiana* (Spreng.) Hyl., to remove the bitter flavour before cooking are encouraged. For *Pteridium aquilinum* var. *latiusculum*, one of the commonest ferns eaten in Asia, it is recommended that it be washed with (salt) water or placed under acidic (e.g., acetic acid) or alkaline conditions (e.g., wood ash or sodium bicarbonate) for several hours to remove or neutralize its toxicity before cooking (Liu et al., 2012; Tourchi-Roudsari, 2014).

SOURCES OF STARCH

A total of 34 fern species was classified in the category of starch suppliers (Table 1). In many species of *Cibotium*, *Pteridium*, Cyatheaceae, and Marattiaceae, starch is stored in their massive stems, rhizomes and, in the latter, in stipules. For instance: *Cyathea spinulosa* (Wall. ex Hook.) R.M.Tryon may possess 64.85% of total carbohydrates (including starch) content in its tender rachis and pith (Kalita et al., 2014); *Cibotium*

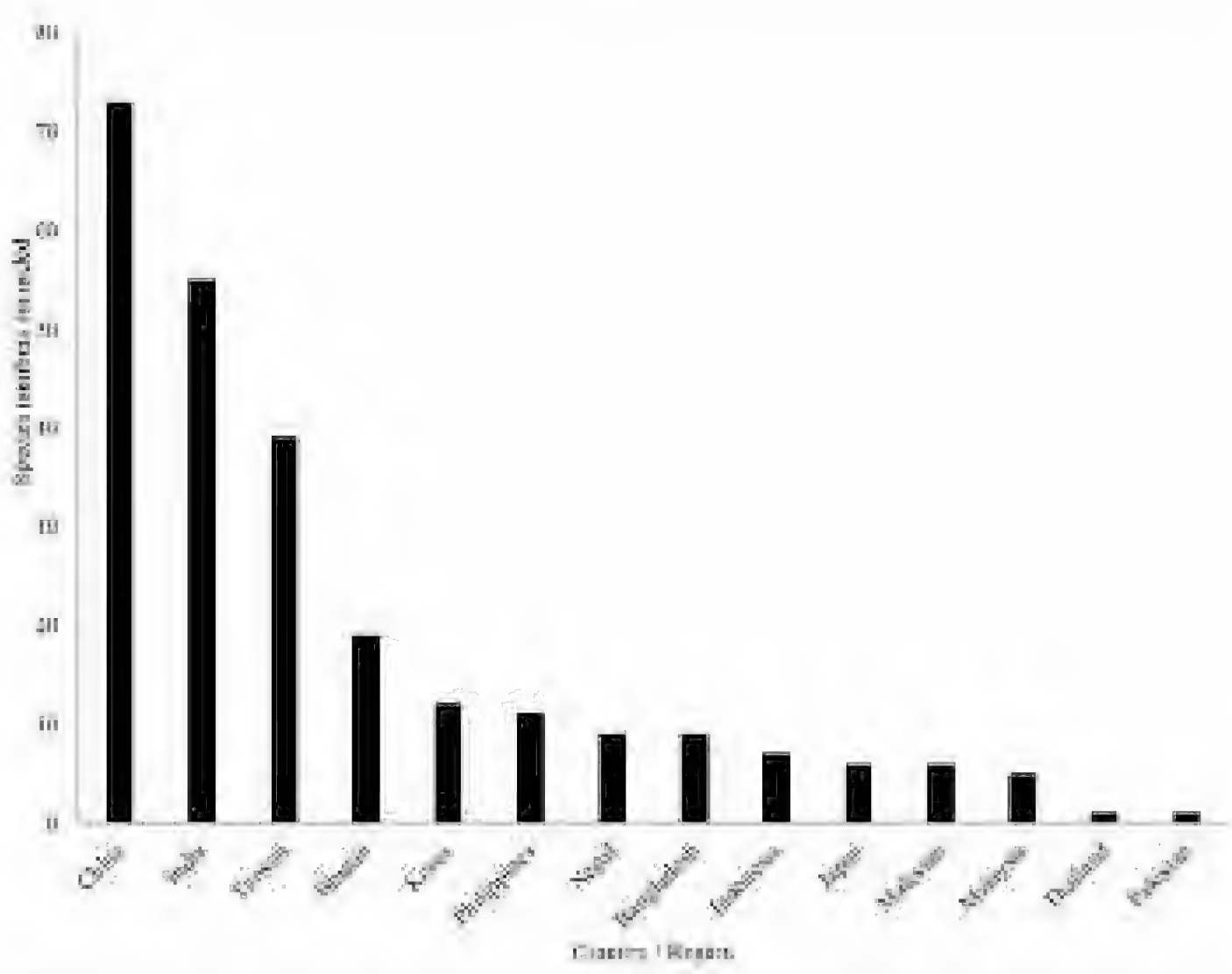

Figure 3. Species number recorded of edible ferns used in different countries/regions in Asia.

barometz (L.) J.Sm. has ca. 30% of starch in its rhizomes (Cao et al., 2007). Starch is also found in species of other families, and *Acrostichum aureum* L. (Pteridaceae) may contain 53% of starch in its rhizomes (Lobo & Gulimane, 2015); *Matteuccia struthiopteris* (L.) Tod. (Onocleaceae) may have up to 40% of its dry weight as starch (Hovenkamp et al., 2016). The amylum (starch) therein is usually extracted to serve as a supplementary food source or to produce alcohol (de Winter & Amoroso, 2003). For example, starch of *Pteridium aquilinum* var. *latiusculum*, extracted from its rhizomes, can be made into various Chinese bread, fern cakes, and fern noodle (Cao et al., 2007; Liu et al., 2012). The starch-rich rhizomes of many *Coniogramma* species are also made into noodles (Yun et al., 2009; Liu et al., 2012). The swollen caudex and stipules of many species of the family Marattiaceae and the stem pith of the tree ferns are known to have rich starch content and are often cooked to produce cakes or substitutes for staple foods (Sundriyal et al., 1998; de Winter & Amoroso, 2003; Srivastava & Khare, 2007; Aya-ay, 2016). Southeast Asian people often cut the starchy stem pith of tree ferns into smaller pieces and steam them with rice (de Winter & Amoroso, 2003).

BEVERAGES

Ferns can be made into herbal tea and alcohol. Herbal tea is widely consumed by Asian people to prevent or relieve internal body heat as well as to improve or maintain good health (Liu et al., 2013). In this review, 15 fern species used for herbal tea are recorded

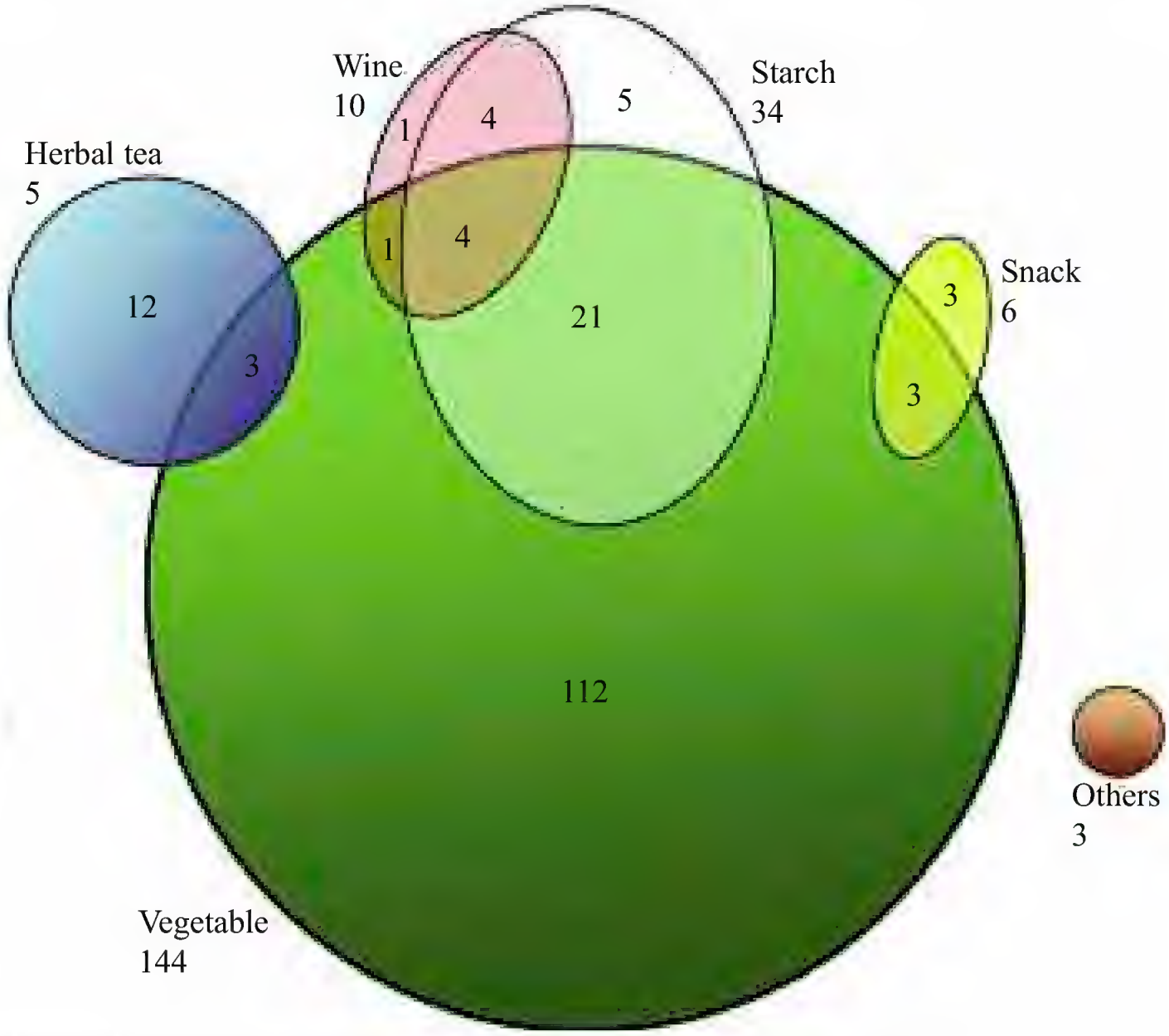

Figure 4. Species number recorded of edible ferns for different usages.

(Table 1). Many ferns are part of the ingredients of herbal tea. A herbal tea is made with leaves of a single fern species or, more often, made from a mixture of several species of ferns or with other vascular plants (Huang et al., 2018). It is worth noting that herbal tea and herbal medicine are often not easily distinguished; for example, *Selaginella tamariscina* (P.Beauv.) Spring is prepared as a herbal tea in China, but it is used to treat a cough in Malaysia (de Winter & Amoroso, 2003). In this article, we only address use as a herbal tea rather than as a medicine.

Ten fern species were found to be used to produce alcoholic beverages (Table 1). Some fleshy/massive rhizomes of ferns (e.g., species of *Cibotium*, *Woodwardia*, *Osmunda*) are rich in starch, which can be extracted and used to produce liquor (Table 1).

Figure 5. Vegetable ferns. Fresh ferns sold in a market of Taiwan: *Diplazium esculentum* (A); *Asplenium australasicum* (B). Fern cuisine in a restaurant of Taiwan: salad-blended *Diplazium esculentum* (C); fried *Asplenium australasicum* (D). Fern cultivated in the field: *Diplazium esculentum* (E); *Asplenium australasicum* (F).

On the other hand, some liquor is made from fern leaves, which serve as part of or a main ingredient, e.g. *Asplenium australasicum* (J.Sm.) Hook. (Council of Agriculture, 2018).

SNACKS AND OTHER USAGES

Only a few ferns are used for snacks. The fresh tubers of *Nephrolepis cordifolia* (L.) C.Presl are eaten raw as snacks in many Asian countries (de Winter & Amoroso, 2013; Huang et al., 2018). The rhizomes of *Davallia griffithiana* Hook. are used as a substitute for betel nut by Taiwanese aboriginal people. Furthermore, some aboriginal natives of central Taiwan use the boiled adventitious buds of *Monachosorum henryi* Christ as a snack when going hunting (Huang et al., 2018). *Isoetes debii* P.K.Shukla, G.K.Srivastava & S.K.Shukla is sometimes used for preparing Pakori, a popular snack in India (Yumkham et al., 2016). Three aquatic species, i.e., *Azolla pinnata* R.Br., *Salvinia cucullata* Roxb., and *Salvinia natans* (L.) All., are used as a substitute for baking soda in India (de Winter & Amoroso, 2003; Yumkham et al., 2016; Singh, 2017; 2018).

POSSIBLE DANGERS AND RISKS OF FERN CONSUMPTION

With the increasing tendency to use ferns as a part of our diet, some other issues have to be kept in mind. Some edible ferns are capable of absorbing and accumulating (heavy) metals, e.g., *Blechnopsis orientalis* (L.) C.Presl (*Blechnum orientale* L.; Zhu et al., 2013), *Asplenium australasicum*, etc. (Dhir, 2018 and references therein), and hence are potentially toxic as food. A warning should be declared when those species are collected for food in such metal-rich environments.

More exploration of phyto-chemical components in edible ferns and their effects on human health is also necessary, not only for those traditionally used ferns but also those in current use. The toxic effects of *Pteridium aquilinum* (*sensu lato*, commonly called bracken) on animals and humans has been long studied (Alonso-Amelot & Avendano, 2002; Vetter, 2009; 2011). Negative effects on humans and livestock by carcinogenic compounds are pronounced when bracken is consumed over a period of time (e.g., Evans et al., 1971, Hirono et al., 1972; Hodge, 1973; Hirono, 1993; Potter & Baird, 2000). Although approaches of removing or neutralizing toxicity of raw plants, such as washing, salting, pickling, drying, full cooking, etc., have been experienced in many regions, people, especially those living in very remote tribes, should be encouraged not to consume this fern for a long period. Recently, harmful effects on mice have been demonstrated within a span of 180 days, following daily feeding of cooked *Diplazium esculentum* (Retz.) Sw., one of the most popular edible ferns, (Roy et al., 2013; Roy & Chaudhuri, 2016). *Diplazium esculentum* has never been reported to be poisonous to humans but nevertheless, its consumption over long periods is not recommended here before there have been in-depth studies of its effect on humans.

CONCLUSION AND FUTURE ASPECTS

There has been a growing interest in ethnobotany, including the use of edible plants, although in many cases the boundary between terms of ancient ethnic and contemporary use is vague (Keller & Prance, 2015). This has encouraged people to exploit the potential usages of plants for enhancing diversity in their diet. Nowadays many edible ferns and their related products are not only seen in traditional markets but are often also available in modern restaurants and supermarkets. Some of them have been cultivated. For example, in Taiwan, the two most common fern vegetables, i.e., *Diplazium esculentum*

Table 1 List of Asiatic edible ferns (and lycophytes)

Current scientific name[i)]	**Used parts**[ii)]	**Usages**[iii)] **(Country)**[iv)]	**References and synonyms**[v)]
Isoetaceae			
Isoetes debii P.K. Shukla, G.K. Srivastava & S.K. Shukla	Leaves	Snack (IN)	1
Lycopodiaceae			
Phlegmariurus phlegmaria (L.) Holub	Leaves	Herbal tea (IN)	1: *Huperzia phlegmaria*
Phlegmariurus squarrosus (G. Forst.) Á. Löve & D. Löve	Leaves	Herbal tea (IN)	1: *Huperzia squarrosa*
Selaginellaceae			
Selaginella tamariscina (P. Beauv.) Spring	Leaves	Herbal tea (CN, K)	2, 3
Aspleniaceae			
Asplenium antiquum Makino	Leaves	Vegetable (TW)	4
Asplenium nidus L.	Leaves	Vegetable (CN, IN, TW)	4, 5, 6; 7, 8: *Neottopteris nidus*
Asplenium australasicum (J. Sm.) Hook.	Leaves	Vegetable / Wine (TW)	4, 9
Asplenium trichomanes L.	Leaves	Vegetable (IN)	10
Athyriaceae			
Athyrium sp. (local name: Gasha daway)	Leaves	Vegetable (BT)	11
Athyrium acutipinnulum Kodama ex Nakai	Leaves	Vegetable (K)	3,12
Athyrium brevifrons Nakai ex Tagawa	Leaves Stems	Vegetable (CN, K) Starch (CN)	3, 12, 13; 8: *Athyrium brevifrons & A. multidentatum*
Athyrium decurrentialatum (Hook.) Copel.	Leaves	Vegetable (CN)	8: *Cornopteris decurrenti-alata*
Athyrium distentifolium Tausch ex Opiz	Leaves	Vegetable (K)	12
Athyrium kuratae Serizawa	Leaves Stems	Vegetable (CN) Starch / Wine (CN)	14

Athyrium multidentatum (Döll) Ching	Leaves	Vegetable (CN)	15
Athyrium niponicum (Mett.) Hance	Leaves	Vegetable (K)	3
Athyrium pachyphyllum Ching	Leaves	Vegetable (CN)	7, 8
Athyrium schimperi Moug. ex Fée	Leaves	Vegetable (IN)	16
Athyrium yokoscense (Franch. & Sav.) Christ	Leaves	Vegetable (CN, K)	7, 8; 3: *Asplenium yokoscense*
Deparia acrostichoides (Sw.) M. Kato	Leaves	Vegetable (IN)	10: *Diplazium acrostichoides*
Deparia boryana (Willd.) M. Kato (local name: Zoekey)	Leaves	Vegetable (BT, IN)	17, 18
Deparia coreana (Christ) M. Kato	Leaves	Vegetable (CN)	8: *Lunathyrium coreanum*
Deparia japonica (Thunb.) M. Kato	Leaves	Vegetable (CN)	7: *Athyrium japonica* & *Athyriopsis japonica* var. *oshimense*
Deparia petersenii (Kunze) M. Kato	Leaves	Vegetable (CN)	8: *Athyriopsis japonica* var. *oshimense*
Deparia pycnosora (Christ) M. Kato	Leaves	Vegetable (CN)	8: *Lunathyrium acrostichoides*
Diplazium sp. (local name: Nakey)	Leaves	Vegetable (BT)	17
Diplazium sp. (local name: Tonkey dawey)	Leaves	Vegetable (BT)	11
Diplazium cf. *laxifrons* Rosenst. (local name: Sawni nigro)	Leaves	Vegetable (BT)	17: *Diplazium laxifrons*?
Diplazium cf. *maximum* (D. Don) C. Chr. (local name: Kali nigro)	Leaves	Vegetable (BT)	17: *Diplazium maximum*?
Diplazium asperum Blume	Leaves	Vegetable (BA, IN, PH)	19; 16, 20, 21: *Diplazium polypoides*
Diplazium axillare Ching	Leaves	Vegetable (CN, IN)	7, 8: *Allantodia himalayensis*; 18: *Diplazium himalayense*
Diplazium dilatatum Blume	Leaves	Vegetable (CN, TW, IN)	4, 18; 7, 8: *Allantodia dilatata*
Diplazium donianum (Mett.) Tardieu	Leaves	Vegetable (TW)	4
Diplazium esculentum (Retz.) Sw.	Leaves	Vegetable (BA, BT, CN, ID, IN, MA, PH, TL, TW)	1, 4, 5, 6, 11, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31; 12, 32, 33, 34: *Athyrium esculentum*; 7, 8: *Callipteris esculenta*

Current scientific name[i)]	Used parts[ii)]	Usages[iii)] (Country)[iv)]	References and synonyms[v)]
Diplazium esculentum (Retz.) Sw. var. *pubescens* (Link) Tardieu & C. Chr.	Leaves	Vegetable (CN)	7, 8: *Callipteris esculenta* var. *pubescens*
Diplazium forrestii (Ching ex Z.R. Wang) Fraser-Jenk.	Leaves	Vegetable (IN)	18
Diplazium giganteum (Baker) Ching	Leaves	Vegetable (CN)	7, 8: *Allantodia gigantea*
Diplazium kawakamii Hayata	Leaves	Vegetable (IN, TW)	18, 4
Diplazium laxifrons Rosenst.	Leaves	Vegetable (BT, TW)	11, 4
Diplazium maximum (D. Don) C. Chr.	Leaves	Vegetable (BT, IN)	11, 17, 18; 10: *Diplazium frondosum*
Diplazium repandum Blume	Leaves	Vegetable (ID)	29
Diplazium sikkimense (C.B. Clarke) C. Chr.	Leaves	Vegetable (IN)	18
Diplazium spectabile (Wall. ex Mett.) Ching	Leaves	Vegetable (CN, IN)	18; 8: *Allantodia spectabilis*
Diplazium squamigerum (Mett.) C. Hope	Leaves	Vegetable (J)	12
Diplazium succulentum (C.B. Clarke) C. Chr.	Leaves	Vegetable (IN)	18
Diplazium viridissimum Christ	Leaves	Vegetable (CN, TW)	4; 7, 8: *Allantodia viridissima*
Azollaceae			
Azolla pinnata R. Br.	Leaves	Other (Substitute for baking soda) (IN, PH)	1, 35
Blechnaceae			
Blechnopsis orientalis (L.) C. Presl	Leaves	Vegetable (BA, CN, ID, IN, MA, PH, TW)	4; 1, 7, 8, 20, 24, 27, 29, 31, 33, 34: *Blechnum orientale*
	Stems	Starch (ID, IN, MA)	
Stenochlaena palustris (Burm. f.) Bedd.	Leaves	Vegetable (IN, MA, PH)	1, 12, 24, 28, 34
Woodwardia japonica (L. f.) Sm.	Stems	Starch (CN) / Wine (CN)	7, 8, 13
Woodwardia unigemmata (Makino) Nakai	Stems	Starch (CN) / Wine (CN)	7, 8
Cibotiaceae			

Cibotium barometz (L.) J. Sm.	Leaves Stems	Vegetable (TW) Starch (CN, TW) / Wine (CN)	4, 7, 8, 13
Cibotium taiwanense C.M. Kuo	Leaves Stems	Vegetable (TW) Starch (TW)	4
Cyatheaceae			
Alsophila costularis Baker	Leaves	Vegetable (IN)	18: *Cyathea chinensis*
Alsophila podophylla Hook.	Stems	Starch (TW)	4
Alsophila spinulosa (Wall. ex Hook.) R.M. Tryon	Leaves Stems	Vegetable (TW) Starch (CN, IN, TW)	4, 7, 8, 13; 5, 6: *Cyathea spinulosa*
Sphaeropteris brunoniana (Wall. ex Hook.) R.M. Tryon	Leaves	Vegetable (PH)	31: *Cyathea contaminans*
Sphaeropteris lepifera (J. Sm. ex Hook.) R.M. Tryon	Leaves Stems	Vegetable (TW) Starch (TW)	4
Davalliaceae			
Davallia griffithiana Hook.	Stems	Snack (Substitute for betel nut) (TW)	4
Dennstaedtiaceae			
Dennstaedtia smithii (Hook.) T. Moore	Leaves	Vegetable (TW)	4
Microlepia sp. (local name: Chimatachim)	Leaves	Vegetable (BT)	17
Microlepia cf. *firma* Mett. ex Kuhn (local name: Tetay negro)	Leaves	Vegetable (BT)	17: *Microlepia firma*?
Microlepia strigosa (Thunb.) C. Presl	Leaves	Vegetable (BA)	20
Monachosorum henryi Christ	Buds	Vegetable (CN) / Snack (CN, TW)	4, 7
Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underw. ex A. Heller	Leaves Stems	Vegetable (BT, CN, IN, J, K, PH, TW) / Snack (CN, IN) Starch (CN, IN, K) / Wine (CN)	1, 3, 4, 7, 8, 10, 11, 12, 14, 15, 16, 19, 33, 36, 37, 38, 39, 40, 41: *Pteridium aquilinum*
Pteridium esculentum (G. Forst.) Cockayne	Leaves	Vegetable (CN)	7

Current scientific name[i)]	Used parts[ii)]	Usages[iii)] (Country)[iv)]	References and synonyms[v)]
Pteridium revolutum (Blume) Nakai	Leaves Stems	Vegetable (BT, CN, TW) Starch (CN) / Wine (CN)	4, 7, 8, 13, 14, 17
Diplaziopsidaceae			
Diplaziopsis javanica (Blume) C. Chr.	Leaves	Vegetable (IN)	18: *Diplazium javanicum*
Dryopteridaceae			
Arachniodes sp. (local name: Keycha hechuem)	Leaves	Vegetable (BT)	17
Arachniodes cf. *henryi* (Christ) Ching (local name: Kem nachum)	Leaves	Vegetable (BT)	17: *Arachniodes henryi*?
Bolbitis angustipinna (Hayata) H. Ito	Leaves	Vegetable (TW)	4
Cyrtomium fortunei J. Sm.	Leaves Stems	Vegetable (CN, K) Herbal tea (CN)	2, 3, 7, 8
Dryopteris cochleata (Buch.-Ham. ex D. Don) C. Chr.	Leaves	Vegetable (N)	42
Dryopteris crassirhizoma Nakai	Stems	Vegetable (K)	3, 40, 43
Dryopteris lepidopoda Hayata	Leaves	Vegetable (TW)	4
Dryopteris marginata (C.B. Clarke) Christ	Leaves	Vegetable (IN)	44
Dryopteris odontoloma (Bedd.) C. Chr.	Leaves	Vegetable (IN)	16
Dryopteris ramosa (C. Hope) C. Chr.	Leaves	Vegetable (PA)	45
Dryopteris wallichiana (Spreng.) Hyl.	Leaves	Vegetable (IN)	16
Pleocnemia irregularis (C. Presl) Holttum	Leaves	Vegetable (MA)	25, 46
Equisetaceae			
Equisetum arvense L.	Stems	Vegetable (CN, J, K)	3, 7, 41, 43
Equisetum hyemale L.	Stems	Herbal tea (CN)	2
Equisetum ramosissimum Desf.	Stems	Vegetable (CN)	7: *Hippochaete ramosissima*
Equisetum ramosissimum Desf. subsp. *debile* (Roxb. ex Vaucher) Hauke	Stems	Vegetable (CN)	7: *Hippochaete debilis*

Gleicheniaceae			
Dicranopteris linearis (Burm. f.) Underw.	Leaves Stems	Vegetable (CN, IN) Starch (IN)	1, 5, 6, 7
Dicranopteris pedata (Houtt.) Nakaike	Leaves Stems	Vegetable (CN) Vegetable (CN)	7
Lindsaeaceae			
Odontosoria chinensis (L.) J. Sm.	Leaves	Herbal tea (IN, TW)	4; 1: *Sphenomeris chinensis*
Lygodiaceae			
Lygodium flexuosum (L.) Sw.	Leaves	Vegetable (IN, N)	5, 6, 47
Lygodium japonicum (Thunb.) Sw.	Leaves Spores	Vegetable (CN) / Herbal tea (IN) Herbal tea (CN)	1, 2, 7, 8
Lygodium microphyllum (Cav.) R. Br.	Leaves	Vegetable (IN)	24
Marattiaceae			
Angiopteris sp.	Stems	Starch (IN) / Wine (IN)	33
Angiopteris esculenta Ching	Stems	Starch (CN)	8, 13
Angiopteris evecta (G. Forst.) Hoffm.	Leaves Stems	Vegetable (BA) Vegetable (BA, IN)	1, 19, 20
Angiopteris fokiensis Hieron.	Leaves Stems	Vegetable (CN) Starch (CN)	7, 8, 13
Angiopteris indica Desv.	Stems	Starch (IN)	18
Angiopteris lygodiifolia Rosenst.	Leaves Stems	Vegetable (TW) Starch (TW)	4
Angiopteris wallichiana C. Presl	Stems	Wine (IN)	27
Ptisana salicina (Sm.) Murdock	Roots / Stems	Starch (IN)	42: *Marattia salicina* Sm.
Marsileaceae			
Marsilea minuta L.	Leaves	Vegetable (BA, IN, PH, TW)	1, 4, 20, 44, 24, 27, 28: *Marsilea crenata*

Current scientific name[i)]	Used parts[ii)]	Usages[iii)] (Country)[iv)]	References and synonyms[v)]
Marsilea quadrifolia L.	Leaves	Vegetable (CN)	7, 8
Nephrolepidaceae			
Nephrolepis acutifolia (Desv.) Christ	Leaves	Vegetable (MA)	35, 46
Nephrolepis biserrata (L.) C. Presl	Leaves	Vegetable (IN, TW)	1, 4
Nephrolepis cordifolia (L.) C. Presl	Leaves Tubers	Vegetable / Snack (Substitute for water) (CN, IN, TW)	1, 5, 4, 6, 16, 27; 7, 8, 13: *Nephrolepis auriculate*
Nephrolepis hirsutula (G. Forst.) C. Presl	Leaves	Vegetable (MR)	35
Onocleaceae			
Matteuccia struthiopteris (L.) Tod.	Leaves Stems	Vegetable (BT, CN, J, K, N) Starch (CN)	3, 8, 11, 12, 15, 37, 41, 48, 13
Pentarhizidium intermedium (C. Chr.) Hayata	Leaves	Vegetable (CN)	7, 8: *Matteuccia intermedia*
Pentarhizidium orientale (Hook.) Hayata	Leaves	Vegetable (CN)	7, 8: *Matteuccia orientalis*
Ophioglossaceae			
Botrypus virginianus (L.) Michx.	Roots	Vegetable (IN)	49: *Botrychium virginianum*
Helminthostachys zeylanica (L.) Hook.	Leaves	Vegetable (ID, IN, MA, PH, TW)	4, 33, 49, 50; 32, 34: *Helminthostachys* sp.
Japanobotrychum lanuginosum (Wall. ex Hook. & Grev.) Nishida ex Tagawa	Leaves	Vegetable (IN, N)	16, 50: *Botrychium lanuginosum*
Ophioglossum nudicaule L. f.	Leaves	Vegetable (N)	51
Ophioglossum polyphyllum A. Braun ex Seub.	Leaves	Vegetable (CN)	8, 50
Ophioglossum reticulatum L.	Leaves	Vegetable (ID, IN, N)	1, 19, 24, 47
Ophioglossum vulgatum L.	Leaves	Vegetable (CN, IN)	1, 7, 37, 19
Sceptridium ternatum (Thunb.) Lyon	Leaves	Vegetable (J)	41: *Botrychium ternatum*
Osmundaceae			
Osmunda claytoniana L.	Leaves	Vegetable (CN)	7

Osmunda japonica Thunb.	Leaves Stems	Vegetable (CN, J, K, TW) Starch / Wine (CN)	3, 4, 7, 12, 8, 36, 37, 40, 41, 43
Osmunda javanica Blume	Leaves	Vegetable (CN)	7
Osmunda regalis L.	Leaves	Vegetable (IN)	12, 1
Osmunda vachellii Hook.	Leaves	Vegetable (CN)	7
Osmundastrum cinnamomeum (L.) C. Presl	Leaves	Vegetable (CN)	8; 7, 13: *Osmunda cinnamomea*
Polypodiaceae			
Drynaria baronii Diels	Stems	Starch (CN)	8, 13
Drynaria coronans (Wall. ex Mett.) J. Sm. ex T. Moore	Leaves Stems	Vegetable (TW) Vegetable (TW)	4: *Aglaomorpha coronans*
Drynaria pleuridioides C. Presl	Stems	Snack (betel nut substitute) (MR)	35
Drynaria rigidula (Sw.) Bedd.	Leaves	Vegetable (ID)	33
Drynaria roosii Nakaike		Stems	Starch / Wine (CN)
Drynaria sparsisora (Desv.) T. Moore	Leaves / Stems	Vegetable / Snack (betel nut substitute) (MR)	35
Goniophlebium niponicum (Mett.) Bedd.	Leaves	Vegetable (CN)	7, 8: *Polypodiodes niponica*
Lemmaphyllum carnosum (Wall. ex J. Sm.) C. Presl	Leaves	Vegetable (CN)	33: *Drymoglossum carnosum*
Lemmaphyllum microphyllum C. Presl	Leaves	Vegetable (CN)	33: *Drymoglossum subcordatum*
Microsorum membranaceum (D. Don) Ching	Leaves	Vegetable (TW)	4
Microsorum punctatum (L.) Copel.	Leaves	Vegetable (IN)	1
Pyrrosia lingua (Thunb.) Farw.	Leaves	Herbal tea (CN)	2
Pteridaceae			
Acrostichum aureum L.	Leaves	Vegetable (PH)	52
Adiantum capillus-veneris L.	Leaves	Herbal tea (IN)	5

Current scientific name[i)]	Used parts[ii)]	Usages[iii)] (Country)[iv)]	References and synonyms[v)]
Calciphilopteris ludens (Wall. ex Hook.) Yesilyurt & H. Schneid.	Leaves	Herbal tea (CN)	2: *Doryopteris ludens*
Ceratopteris pteridoides (Hook.) Hieron.	Leaves	Vegetable (BA)	20
Ceratopteris thalictroides (L.) Brongn.	Leaves	Vegetable (BA, CN, IN, N, PH, TW)	1, 4, 7, 8, 20, 24, 47; 32: *Ceratopteris siliquosa*
Cheilanthes chusana Hook.	Leaves	Herbal tea (TW)	4
Coniogramme affinis (C. Presl) Hieron.	Leaves Stems	Vegetable (CN) Starch (CN)	7: *Coniogramme affinis* & *C. affinis* var. *pilosa*
Coniogramme caudiformis Ching & K.H. Shing	Leaves Stems	Vegetable (CN) Starch (CN)	7
Coniogramme emeiensis Ching & K.H. Shing	Leaves Stems	Vegetable (CN) Starch (CN)	7, 8
Coniogramme falcipinna Ching & K.H. Shing	Leaves Stems	Vegetable (CN) Starch (CN)	7: *Coniogramme falcipinna* & *C. falcipinna* var. *pilocostata*
Coniogramme intermedia Hieron.	Leaves Stems	Vegetable (CN) Starch (CN)	7; 8: *Coniogramme intermedia*, *C. maxima* & *C. simileima*
Coniogramme intermedia Hieron. var. *glabra* Ching	Leaves Stems	Vegetable (CN) Starch (CN)	7, 8
Coniogramme japonica (Thunb.) Diels	Leaves Stems	Vegetable (CN) Starch (CN)	8; 7: *Coniogramme japonica* & *C. centrochinensis*
Coniogramme jinggangshanensis Ching & K.H. Shing	Leaves Stems	Vegetable (CN) Starch (CN)	7, 8
Coniogramme robusta (Christ) Christ	Leaves Stems	Vegetable (CN) Starch (CN)	7, 8
Coniogramme rosthornii Hieron.	Leaves Stems	Vegetable (CN) Starch (CN)	7, 8: *Coniogramme rosthornii* & *C. taipaishanensis*
Coniogramme wilsonii Hieron.	Leaves Stems	Vegetable (CN) Starch (CN)	7, 8
Onychium japonicum (Thunb.) Kunze	Leaves	Herbal tea (TW)	4

Pteris cretica L.	Leaves	Vegetable (CN)	7
Pteris ensiformis Burm. f.	Leaves	Herbal tea (TW)	4
Pteris fauriei Hieron.	Leaves	Herbal tea / Vegetable (CN)	7
Pteris multifida Poir.	Leaves	Herbal tea (TW)	4
Pteris terminalis Wall. ex J. Agardh	Leaves	Vegetable (BT)	11: *Pteris excelsa*
Pteris wallichiana J. Agardh	Leaves	Vegetable (BT, CN, TW)	4, 7, 8, 17
Pteris cf. *wallichiana* J. Agardh (local name: Api kem)	Leaves	Vegetable (BT)	17: *Pteris wallichiana* or *P. spinescens*
Salviniaceae			
Salvinia cucullata Roxb.	Leaves	Other (Substitute for baking soda) (IN)	1, 5, 6
Salvinia natans (L.) All.	Leaves	Other (Substitute for baking soda) (IN)	1
Tectariaceae			
Arthropteris palisotii (Desv.) Alston	Leaves	Vegetable (TW)	4
Tectaria coadunata (J. Sm.) C. Chr.	Leaves	Vegetable (IN, N)	19 47: *Tectaria macrodonta*
Tectaria crenata Cav.	Leaves	Vegetable (MR)	35; *Aspidium crenatus* (Cav.) Ching
Tectaria fuscipes (Wall. ex Bedd.) C. Chr.	Leaves	Vegetable (IN)	18
Tectaria gemmifera (Fée) Alston	Leaves	Vegetable (MR)	35
Tectaria paradoxa (Fée) Sledge	Leaves	Vegetable (MR)	35
Thelypteridaceae			
Cyclogramma auriculata (J. Sm.) Ching	Leaves	Vegetable (N)	47: *Thelypteris auriculata*
Cyclosorus callosus (Blume) Ching	Leaves	Vegetable (ID)	29: *Pneumatopteris callosa*
Cyclosorus dentatus (Forssk.) Ching	Leaves	Vegetable (IN)	53: *Christella dentata*

Current scientific name[i)]	Used parts[ii)]	Usages[iii)] (Country)[iv)]	References and synonyms[v)]
Cyclosorus proliferus (Retz.) Tardieu ex Tardieu & C. Chr.	Leaves	Vegetable (BA, CN, IN, PH)	16, 20, 7, 8, 1: *Ampelopteris prolifera*; 32: *Dryopteris prolifera*
Cyclosorus productus (Kaulf.) Ching	Leaves	Vegetable (TW)	4
Woodsiaceae			
Woodsia polystichoides D.C. Eaton	Leaves	Vegetable (CN)	7

i. Family names following the phylogenetic order of PPG I (2016); Scientific names within family arranged by alphabetic order.
ii. Used parts: **Leaves** including croziers (fiddleheads), young fronds, stalks and tender blades; **Stems** including underground or aboveground rhizomes and aboveground caudexes; **Roots** mainly referring to fleshy roots of Marattiaceae and Ophioglossaceae.
iii. Usages: **Beverage** presented by herbal tea and wine, separately; **Starch** meaning source of staple food or substitute for staple food; **Vegetable** including greens, pickles, and ingredients of salad or soup.
iv. Code of country or regions: BA – Bangladesh, BT – Bhutan, CN – China, ID – Indonesia, IN – India, J – Japan, K – Korean Peninsula, MA – Malaysia, MR – Malesian Region, N – Nepal, PA – Pakistan, PH – the Philippines, TL – Thailand, TW – Taiwan.
v. References: 1. Yumkham *et al*., 2016; 2. Liu *et al*., 2013; 3. Chung *et al*., 2016; 4. Huang *et al*., 2018; 5. Singh, 2017; 6. Singh, 2018; 7. Yun *et al*., 2009; 8. Liu *et al*., 2012. 9. COA. 2018; 10. Khan & Hussain, 2014; 11. Matsushima *et al*., 2012; 12. Lee & Shin, 2011; 13. Cao *et al*., 2007; 14. Zhang *et al*., 2016; 15. Wujisguleng & Khasbagen, 2010; 16. Gaur & Bhatt, 1994; 17. Matsushima *et al*., 2010; 18. Thapa & Lama, 2015; 19. Dobriyal & Dobriyal, 2014; 20. Sarker & Hossain, 2009; 21. Delos Angeles & Buot Jr., 2012.; 22. Sundriyal, *et al*., 1998; 23. Misra *et al*., 2008; 24. Sen & Ghosh, 2011; 25. Ong *et al*., 2012; 26. Sumpavapol *et al*., 2012; 27. Mitra & Mukherjee, 2013; 28. Amoroso *et al*., 2014; 29. Sujarwo *et al*., 2014; 30. Thongpukdee *et al*., 2014; 31. Aya-Ay, 2016; 32. Copeland, 1942; 33. May, 1978; 34. Hoe & Siong, 1999; 35. de Winter and Amoroso, 2003; 36. Hodge, 1973; 37. Ju *et al*., 2013; 38. Shin *et al*., 2013; 39. Song et al., 2013; 40. Ong *et al*., 2015; 41. Matsushima *et al*., 2013; 42. Turin, 2003; 43. Shin *et al*., 2015; 44. Jain *et al*., 2011; 45. Amjad *et al*., 2015; 46. Chai *et al*., 2015; 47. Dangol, 2008; 48. Limbu & Thapa, 2011; 49. Srivastava & Khare, 2007; 50. Lognay *et al*., 2008; 51. Manandhar 2002; 52. Amoroso 1990; 53. Kumar *et al*., 2003.

and *Asplenium australasicum* (Figure 5E, F), are cultivated and their annual products reached to ca. 450 tons (0.63 million USD; 1.4 USD/Kg) and 250 tons (1 million USD; 4 USD/kg), respectively, in 2018 (calculated from data in TWFOOD, 2019a, b). In China, however, most edible ferns are collected from the wild although the annual production value is estimated to be 300 million USD (360,000 tons) for *Pteridium aquilinum* var. *latiusculum* (Liu et al. 2012) and 10 million USD (1 ton) for *Osmunda japonica* Thunb. (Baidu, 2019). This commercial application and thus more intensive demand may lead to overharvesting and the destruction of the habitats where they grow, e.g., *Osmunda japonica* in China (Liu et al., 2012). The action of *in situ* conservation and the development of artificial propagation *ex situ* rather than harvesting only from the wild are encouraged (Liu et al., 2012; Keller & Prance, 2015). Techniques of fern spore collection and storage, gametophyte culture, and sporophyte propagation have been developed currently and should be applied for the sustainable use of edible ferns (Ballesteros & Pence, 2018; Johari & Singh, 2018; and reference therein).

In this review, we have presented the diversity of edible ferns and the manner of their use in Asia countries. South, Southeast to East Asia is one of the most fern-rich regions in the world and is the main region addressed in this study. However, in our literature review, we found evidence for edible ferns in only 13 Asian countries, and in some of those countries very few edible fern species were recorded. In addition, only very few species were recorded in countries of the broad geographic region, i.e., Malesian and Indochina Peninsula. The number of edible ferns consumed here must be an underestimate in those countries/regions. Additional ethnobotanical surveys in more parts of Asia are needed to record more valuable species and rare utilization by the ethnic community (Deb et al., 2013). There is also a need to explore the considerable diversity of ferns outside Asia for their use as food (Sundriyal et al., 1998).

Most of the investigations on edible ferns were implemented by ethnopteridologists. Some of the ferns were recorded as local names without specific identification; others were reported as synonyms or might have been misidentified. Here we present current scientific names, following the phylogenetic system of PPG I, to facilitate scientific communication and further studies. However, results for six taxa remain undetermined and five taxa uncertain, indicated with "?" and "aff." in Table 1. The preparation of voucher specimens is strongly encouraged for future work.

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Wen-Liang Chiou is an emeritus curator of the herbarium (TAIF) of the Taiwan Forestry Research Institute (TFRI). He received his B.S. and M.S at the Department of Botany in National Chung-Hsing University, Taiwan and studied his Ph.D. program with Dr. Donald R. Farrar at the Iowa State University, USA. After serving the army of Taiwan for two years, he started his scientific career in TFRI in 1980 and retired in 2014. In addition to studying ferns, he also worked as the director of Forest Biology Division, Botanical Garden Division, Fushan Experimental Forest, and the herbarium of TFRI. His research mainly focuses on ferns and lycophytes including very broad field: taxonomy, systematics, phylogeny, gametophyte morphology, antheridiogen, reproductive biology, phenology, hybridization, evolution, ethnopteridophyte, and so on. Currently he has co-edited two books, coauthored several book chapters, coauthored two monographs (*Selaginella* and *Athyrium* in Taiwan), and (co)authored 100+ scientific articles in peer review journals. After retirement, he has enjoyed traveling widely to collect specimens and spending time on ferns in the herbarium and botanical garden.

Dr. Yao Moan Huang
Contracted researcher of Taiwan Forestry Research Institute

I am broadly interested in the reproductive biology, conservation, phylogeny, usage and systematic of ferns and lycophytes. More than 50 research papers on ferns have been published since 1995. In addition, I and Dr. Wen Liang Chiou co-established the greatest Asian spore bank of ferns and lycophytes in 1998; more than 5,200 accessions representing 807 species have been collected since. Recently, I and my colleagues initiate to explore the diversity of fungi on ferns and the medicine of ferns and lycophytes. Our research team does not only devote to scientific study but also human life.

Mr. Yi-Han Chang
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My main field of studies focuses on systematics of pteridophytes, especially for Dennstaedtiaceae and Thelypteridaceae. In addition, ethnobotany also attracts my interest.

FERNS AND LYCOPHYTES OF CUNIÃ ECOLOGICAL STATION, SOUTH-WESTERN AMAZONIA, BRAZIL

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Key words: Inventory; forest land; west Amazon.

ABSTRACT

An inventory was prepared of ferns and lycophytes at Cuniã Ecological Station, South-Western Amazonia, Brazil, between 2010 and 2015, and 54 species were recorded. Lycophytes were represented by the families Selaginellaceae (two species) and Lycopodiaceae (one species), genera *Selaginella* and *Phlegmariurus*. Fifteen families of ferns were found, with most representatives from Hymenophyllaceae (11 species), Pteridaceae (nine species) and Polypodiaceae (seven species). Twenty five genera were identified; the most species rich were *Trichomanes* (seven species), *Adiantum* (six species), *Asplenium, Lindsaea* and *Microgramma* (four species each). Seven species or subspecies are new records for the state of Rondônia: *Elaphoglossum obovatum*, *Lindsaea lancea* var. *remota*, *Oleandra articulata*, *Cochlidium linearifolium*, *Microgramma reptans*, *Adiantum tuomistoanum* and *Meniscium arborescens*. Concerning life habit, 27 terrestrial species were recorded, 23 epiphytic species and four vines. Two terrestrial species were tree ferns. Fifty two percent of the species preferred one type of habitat, 12 species were exclusively found in riparian areas, 10 in *terra-firme* and six along the trails. The remaining 26 species (48%) were observed in more than one type of habitat.

INTRODUCTION

Ferns and lycophytes are widely distributed around the world (Smith et al., 2006), but

with most occurring in the tropical and subtropical zones, in shady and humid forested areas (Tryon & Tryon 1982). Nowadays, approximately 13,600 species are known and the greatest species richness is found in equatorial regions. Asian South-East (4,500 spp.), South-America (3,500 spp.), Meso-America (1,800 spp.) and the Antilles (1,200 spp.) account for the greatest diversity of both groups (Moran, 2008).

In Brazil, 1,356 species have been described (including 13 subspecies), distributed in 38 family and 155 genera, with 524 species considered endemic (Prado & Sylvestre, 2018; Prado et al., 2015). Phytogeographical domains of Atlantic Forest (834 spp.) and Amazonia (423 spp.) shelter the greatest diversity (Prado & Sylvestre, 2010). In Rondônia state, our compilation of floristic data for lycophytes and ferns revealed the occurrence of 141 species (and two varieties), distributed in 25 families and 66 genera (Barros et al., 2017a, b, c; Dittrich & Salino, 2017; Hirai, 2017; Labiak, 2017; Labiak et al., 2017; Matos, 2017; Mickel et al., 2017; Mynssen, 2017; Prado, 2017a, b, c; Salino & Almeida, 2017a, b: Schwartsburd, 2017a, b; Windisch & Santiago, 2017; Windisch et al., 2017).

Ferns and lycophytes are of significant ecological importance, but at present this is poorly understood (Prado, 1998). Besides being an abundant component of the understory and canopy flora, ferns and lycophytes play a role in the development and establishment of other plants and animals groups in many ecosystems (Smith, 1972). They perform an essential role in maintaining humidity inside the forest, absorbing water and gradually spreading it to soil and air, thus favouring microfauna and substrate microflora development, essential for the maintenance of ecological equilibrium (Brade, 1940). Some species are also indicators of vegetation types, soil and environmental conservation status. (Sharpe et al., 2010; de la Sota, 1971). They also provide significant local scale information on previous and present-day forest status (de la Sota, 1971; Granville, 1984; Barros et al., 1996; Tuomisto & Poulsen, 1996). Some fern species are relevant for soil conservation and restoration processes, given their ability to accumulate and remove toxic chemical compounds (Tu & Ma, 2005).

Ferns and lycophytes are sensitive to human interference, including habitat alteration and the introduction of exotic species, leading to diversity loss (Sharpe et al., 2010). Therefore, there is the need to gain knowledge of this flora in order to trace its ecological profile and provide information for its conservation. This study aims to fill the gap of knowledge of the flora of Rondônia state, and provide a list of ferns and lycophytes and their ecological preferences within the Cunhã Ecological Station, Rondônia, Brazil (ESEC Cunhã), a poorly known area in South-Western Amazonia.

MATERIALS AND METHODS

The study site is part of the Brazilian Biodiversity Research Program (PPBio). The grid of trails covers 25 km^2 in Cunhã Ecological Station (8º4'S, 63º29'W), a Brazilian federal protected area in the state of Rondônia, South-Western Amazonia, accessed through BR 319 highway (Figure 1). It is located in the Madeira paleovarzea, in the Madeira-Purus interfluve, a region with high rainfall (~2,500 mm y^{-1}) and mean annual temperature of 27ºC (Figure 1).

Numerous rivers and dark water lakes form a dense hydrological net, presenting a vegetation mosaic of *terra-firme* forests, flooded areas, white-sand forests and savannah, locally known as *campinas* and *campinaranas* (Maldonado et al., 2009; Pansini et al., 2016). The grids of PPBio consist of a network of 12 trails (six north–south and six east–west; each 1 m in width and 5 km in length) with 30 *terra-firme* permanent plots

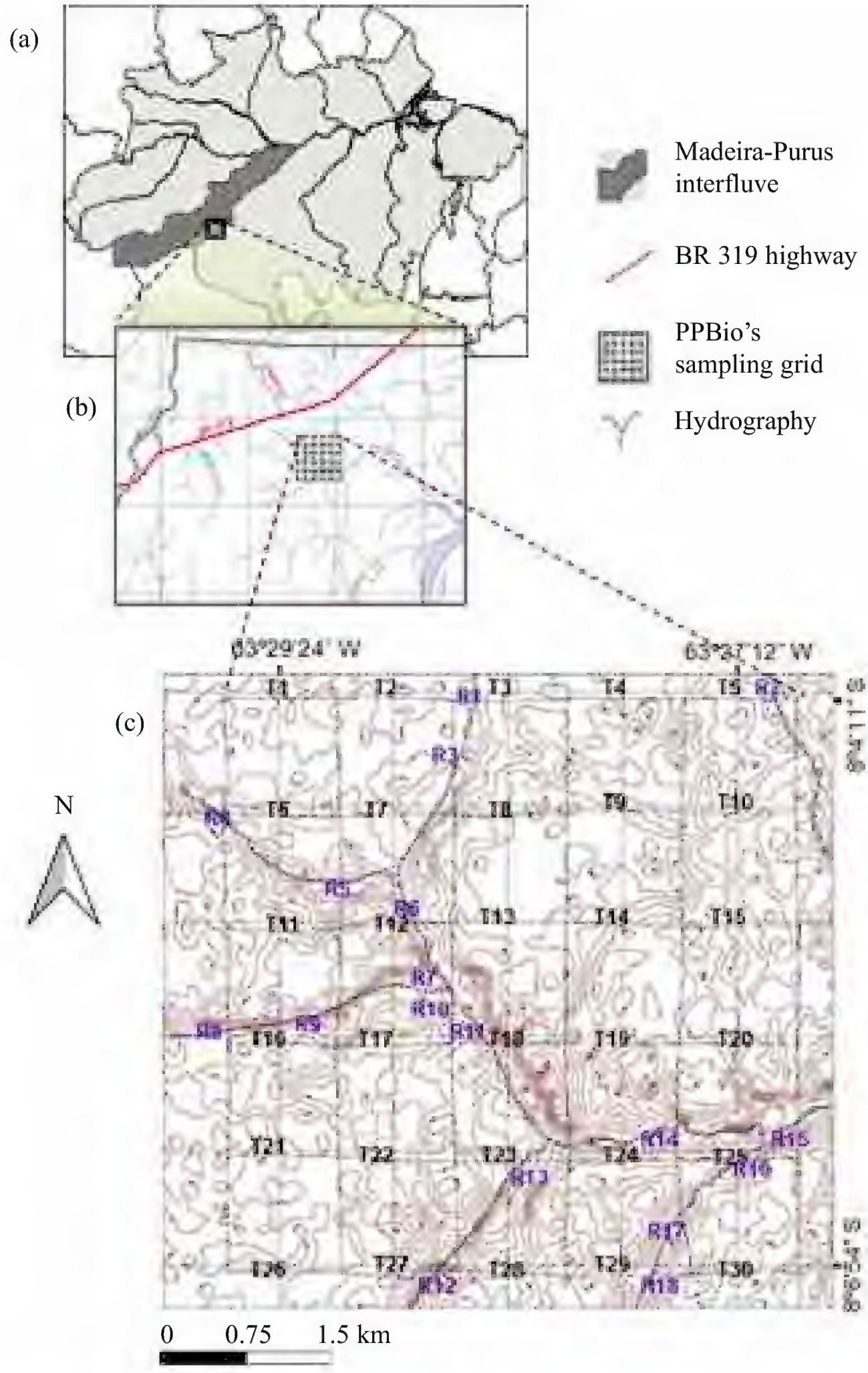

Figure 1: Study area: (a) Brazilian Amazonia and Madeira-Purus interfluves in prominence; (b) Location of PPBio grid of trails inserted in ESEC Cuniã; (c) Location of PPBio *terra-firme* (T 1 – 30) and riparian (R 1 – 18) permanent plots.

distributed systematically every kilometer along the E-W trails and 18 riparian permanent plots distributed along streams inside the grid (Figure 2). Each plot is 250 m in length and 2.5 m wide. *Terra-firme* plots follow topographic contours and riparian plots follow water flow contours (Figure 1) (Magnusson et al., 2005; Pansini et al., 2016).

Data were collected along the 12 trails and in the 48 permanent plots of the PPBio grid between April 2010 and November 2015 (Figure 1). PPG I (2016) was adopted as the classification system and Pichi-Sermolli (1996) for standardization of taxon author names. Voucher specimens were deposited in the herbarium of Rondônia Federal University (RON), the National Institute of Amazonian Research (INPA) and Botanical Institute of São Paulo (SP).

Specimens were classified according to Moffett (2000) life traits: ***Epiphyte*** – fern

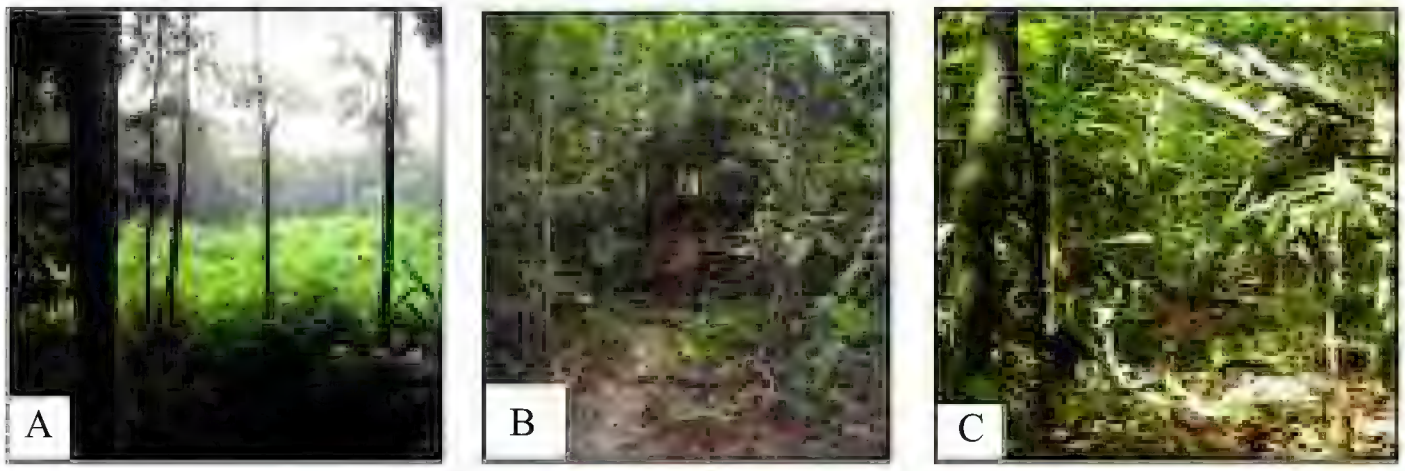

Figure 2: Cuniã Ecological Station, county of Porto Velho Madeira-Purus interfluves in prominence, - Humaitá, Rondônia, Brasil. A, B, C: trails; D, E, F: the plots, illustrating the vegetation; G, H, I: canopy vegetation.

that completes its life cycle on another plant (phorophyte) using it as a mechanical support; ***Nomadic vine*** – plant that starts its life cycle on soil presenting initial delicate non woody stem and later climbs a phorophyte and may or may not loose contact with the ground; ***Terrestrial*** – organism grows directly from the ground, presenting a creeping to erect stem. Terrestrial tree ferns present an erect stem constituted of a fibrous root pulp, which expands as the stem grows. Habitats of species occurrence were classified as ***Terra-firme*** (TF): non-flooded areas without and human intervention; ***Trail*** (T): areas with low-impact human interference due to people flux; ***Riparian*** (R) – areas along creeks with strong water influence and possibly flooded after heavy rainfall.

RESULTS AND DISCUSSION

During the present survey, 54 lycophyte and fern species (Table 1) were collected and registered in the ESEC Cuniã. The lycophytes were represented by the families Selaginellaceae and Lycopodiaceae, and the genera *Selaginella* and *Phlegmariurus,* respectively. Fifteen families of ferns were identified, Hymenophyllaceae (11), Pteridaceae (nine) and Polypodiaceae (seven) being the most common. Twenty five genera were identified, including *Trichomanes* (seven), *Adiantum* (six), *Asplenium, Lindsaea* and *Microgramma* (all with four) being the most numerous and representing 49% of the total collection (see Figure 3).

Seven species are new records for the Rondônia state: *Adiantum tuomistoanum* J.Prado, *Cochlidium linearifolium* (Desv.) Maxon ex C.Chr., *Elaphoglossum obovatum* Mickel, *Lindsaea lancea* var. *remota* (Kunze) Kramer, *Meniscium arborescens* Humb. & Bonpl. ex Willd., *Microgramma reptans* (Cav.) A.R. Sm. and *Oleandra articulata* (Sw.) C. Presl.

Considering the habitat of individuals, terrestrial was the most common with 27 species (46%), followed by epiphyte (23 spp., 43%) then nomadic vine (4 spp., 7 %). The two tree fern species found (*Cyathea microdonta* (Desv.) Domin and *C. pungens* (Willd.) Domin) were restricted to the riparian environment. The predominance of terrestrial species is related to the sampling strategy and it is likely that more epiphytic species occur in the area but were not observed.

We found that 52% of species were restricted to one habitat type; 12 species were found only in riparian areas, 10 in *terra-firme* and six along the trails. The remaining 26 species (48%) were observed in more than one habitat and therefore are able to establish in several environmental conditions, from extremely humid riparian areas to those with greater solar incidence like trails. Among the generalists, *Asplenium serratum* L. was the most common. This epiphyte is widely distributed in plots and trails and occurred in diverse types of phorophyte, on trunks with a dirty rhytidome, with loosened and cracked plates, or on palms trunks (mostly *Lepydocarium tenue* Mart. and *Astrocaryum gynacanthum* Mart.) and roots (*Socratea exorrhiza* (Mart.) H. Wendl. and *Iriartella setigera* (Mart.) H. Wendl). An annotated check-list of the species is presented in Table 1.

The Amazon rainforest is recognised for its complexity, diversity and geographic extent (Scudeller et al., 2009). The variety of natural resources that exist there occurs only as a consequence of the different vegetal associations that grow under the influence of environmental factors intrinsic to each ecosystem that forms this biome (Gama et al., 2003). Among the ecosystems of the Amazon forest, *terra-firme* forest is characterized by high representation by a few individuals of each species (Prance et al., 1976; Lima Filho et al., 2001). It presents an exuberant physiognomy with great biomass, the

understory is usually open with a great concentration of palm trees, and its soil is considered to be poor in nutrients, as much of the organic matter is contained within the body of the plants themselves (Pires, 1972).

Figure 3: Some examples of species found in the ESEC Cuniã. A. *Elaphoglossum obovatum*, B. *Mickelia guianensis*, C. *Lindsaea lancea* var. *lancea*, D. *Danaea leprieurii*, E. *Cochlidium linearifolium*, F. *Microgramma reptans,* G. *Microgramma lycopodioides*, H. *Adiantum tuomistoanum,* I. *Oleandra articulata*.

Ferns and lycophytes are common vascular plants in the sub-forest of the Amazon rainforest, possessing photosynthetic capacity in low amounts of light incidence and with high resistance to diseases in environments with high relative humidity (Page, 2002). However, they are rarely dominant in any type of vegetation, being highly dependent on other plants to provide shelter and support (Holttum, 1938).

The increasing deforestation of vegetation cover in the Amazon has caused immeasurable losses of genetic resources (Nobre et al., 1991; Houghton et al., 2000), where rare species have been decimated and several habitats modified by anthropic actions, affecting the resilience of ecosystems (Silva & Rosário, 2008). Ferns, as well as almost all tropical forest organisms, are threatened by deforestation caused by logging and farming activities. Most mature forest species are not able to grow in other types of environments, such as pastures, plantations, and secondary forests.

In Brazil, Pteridaceae, Dryopteridaceae, Polypodiaceae, Thelypteridaceae, Hymenophyllaceae, Aspleniaceae, Anemiaceae, Selaginellaceae, Lycopodiaceae and Cyatheaceae show the greatest specific diversity (Prado & Sylvestre, 2010). This same trend is observed in Amazonia with Pteridaceae, Polypodiaceae and Dryopteridaceae being the most abundant families (Costa & Nunes, 2004; Freitas & Prado, 2005; Hopkins, 2005; Costa et al., 2006; Costa & Pietrobom, 2007; Zuquim et al., 2008; Prado & Moran, 2009; Costa & Pietrobom, 2010; Maciel et al., 2007).

In the present study *Trichomanes* (seven species), *Adiantum* (six species), *Asplenium, Lindsaea* and *Microgramma* (each with four species), were the most diverse genera. However, *Asplenium* and *Adiantum* are among the five most diverse genera recorded in Brazil (Prado & Sylvestre, 2010). The difference may reflect some features of the phytophysiognomy of the Madeira / Purus interfluve region. The interfluve region presents a wide phytophysiological heterogeneity, with a predominance of *terra-firme* forests, with vegetation formed by the forests: Dense Ombrophilous Lowland with Emergent Canopy in the northern portion and Open Ombrophylous Lowland with Palms in the southern portion. The interfluve forests have different structural characteristics, and may resemble areas of *campinaranas* or form a mosaic of *terra-firme* forest, chestnut, caiague (*Elaeis oleifera* (Kunth) Cortés) and extensive areas of lowland forest without sub-vegetation (Brasil, 1978).

These studies of ferns and lycophytes in the Rondoniense territory are timely. Little was known about the ferns of Rondônia, as reflected in the discovery of seven new records in an area of only 25 Km^2. If we expand sampling efforts here, the number of new records may increase exponentially.

Terretrial herbaceous habit was the most commonly recorded by Prado (2005 a,b,c,d,e,f,g,h,i,j,k,l,m,n), Prado & Labiak (2005), Costa & Prado (2005a,b), Freitas & Windisch (2005), Prado & Freitas (2005), Costa et al. (2006), Costa & Pietrobom (2007) and Fernandes et al. (2012). The understory of tropical forests presents a variety of micro-environmental conditions related to heterogeneity in canopy openness (Hogan & Machado, 2002), soil texture and fertility (Tuomisto & Poulsen, 1996), litter depth (Facelli & Pickett, 1991), pH (Ranal, 1995) and humidity (Page, 2002).

However, the epiphyte form also had high representation (23 species). At a local scale, the coexistence of high numbers of epiphytes is influenced by several factors. The structural complexity of the rainforest in Rondônia may favor the establishment of epiphytic ferns and explain the high number of species observed. Herbicides interfere the establishment, growth and survival of epiphytes (Yeaton & Gladstone, 1982; Akinsoji, 1990; Hietz-Seifert et al., 1996; Hietz, 1997; Nieder et al., 2000; Bonnet et al., 2007),

Table 1. List of species with vouchers in the Herbarium RON, habits and the preferred vegetation type of the species, registered in ESEC Cuniã, in the municipality of Porto Velho, Rondônia, Brazil.* New occurrence for Rondônia.

CLASS/*Family*/*Species*	**Voucher**	**Habit**	**Preferred vegetation type**
LYCOPODIOPSIDA Bartl. 1830			
Lycopodiaceae Mirbel.			
Phlegmariurus linifolius (L.) B.Øllg. var. *jenmanii* (Underw. &. F.E. Lloyd) B.Øllg.	Cabral 10193	E	T
Selaginellaceae Willk, in Willk. & Lange			
Selaginella asperula Spring.	Zuquim 4885	H	TF/R/T
Selaginella parkeri (Hook. & Grev.) Spring	Cunha 1276	H	R/T
POLYPODIOPSIDA Cronquist, Takht. & W.Zimm. 1966			
Aspleniaceae Newman			
Asplenium angustum Sw.	Sampaio 7309	E	TF
Asplenium hallii Hook.	Sampaio 7312	E	T
Asplenium serratum L.	Sampaio 7313	E	TF/R
Asplenium stuebelianum Hieron	Sampaio 7304	E	T
Blechnaceae (C.Presl) Copel.			
Salpichlaena hookeriana (Kuntze) Alston	Cunha 1291	VN	TF/R/T
Cyatheaceae Kaulf.			
Cyathea microdonta (Desv.) Domin	Cunha 1277	A	R
Cyathea pungens (Willd.) Domin	Sampaio 1346	A	R
Dryopteridaceae Herter.			
Cyclodium meniscioides (Willd.)	Cabral 8325	H	R/TF
Elaphoglossum glabellum J.Sm.	Sampaio 7343	E	TF
Elaphoglossum obovatum Mickel *	Sampaio 7319	E	TF/T
Mickelia guianensis (Aubl.) R.C.Moran, Labiak & Sundue *	Cunha 1381	VN	TF/R/T
Hymenophyllaceae Martius.			
Didymoglossum angustifrons Fée	Sampaio 7307	E	T
Didymoglossum pinnatinervium (Jenman) Pic. Serm.	Sampaio 7306	E	T
Didymoglosssum punctatum (Poir.) Desv.	Sampaio 1326	E	T/TF/R
Hymenophyllum polyanthos (Sw.) Sw.	Sampaio 7305	E	T
Trichomanes ankersii C.Parker ex Hook. & Grev.	Sampaio 1374	VN	TF/R/T
Trichomanes elegans Rudge	Sampaio 7311	H	TF/T
Trichomanes hostmannianum (Klotzsch) Kunze	Sampaio 1288	H	TF/R
Trichomanes martiusii C.Presl	Sampaio 1294	E	TF/T
Trichomanes pinnatum Hedw.	Cunha 1273	H	TF/R
Trichomanes tanaicum Hook.	Cunha 1287	VN	R/T
Trichomanes vittaria DC. ex Poir.	Ribeiro 7888	H	TF

Lindsaeaceae C.Presl ex M.R.Schomb.			
Lindsaea guianensis (Aubl.) Dryand.	Ribeiro 7863	H	R
Lindsaea lancea (L.) Bedd. var. *lancea*	Ribeiro 7875	H	TF/R
Lindsaea lancea (L.) Bedd. var. *falcata* (Dryand.) Hieron	Ribeiro 7881	H	TF
Lindsaea lancea var. *remota* (Kunze) Kramer *	Cunha 1358	H	T
Marattiaceae Kaulf.			
Danaea leprieurii Kunze. *	Cunha 1285	H	R
Metaxyaceae Pic. Serm.			
Metaxya rostrata (Kunth) C.Presl	Cunha 1281	H	TF/R
Oleandraceae (J. Sm.) R.C.Ching ex Pic. Serm.			
Oleandra articulata (Sw.) C.Presl *	Sampaio 7328	E	TF
Polypodiaceae J.Presl & C.Presl			
Campyloneurum repens (Aubl.) C.Presl	Sampaio 1342	E	R
Cochlidium linearifolium (Desv.) Maxon ex C.Chr. *	Sampaio 7321	E	TF
Microgramma reptans (Cav.) A.R.Sm. *	Sampaio 1350	E	R
Microgramma lycopodioides (L.) Copel. *	Sampaio 1350	E	TF/R
Microgramma megalophylla (Desv.) de la Sota	Cunha 1271	E	R
Microgramma thurnii (Baker) R.M.Tryon	Sampaio 7333	E	TF
Phlebodium decumanum (Willd.) J.Sm.	Sampaio 7320	E	TF/R
Pteridaceae Reichb.			
Adiantum cajennense Willd. ex Klotzsch	Cunha 1283	H	TF/R
Adiantum humile Kunze	Ribeiro 7889	H	R/T
Adiantum obliquum Willd.	Ribeiro 7887	H	R
Adiantum terminatum Kunze ex Miq.	Sampaio 71347	H	R
Adiantum tomentosum Klotzsch	Zuquim 4881	H	TF/R
Adiantum tuomistoanum J.Prado *	Zuquim 4888	H	TF
Hecistopteris pumila (Spreng.) J.Sm.	Sampaio 7351	E	TF/R
Polytaenium guayanense (Hieron.) Alston	Sampaio 7337	E	TF
Vittaria lineata (L.) Sm.	Sampaio 7325	E	TF/T
Saccolomataceae Doweld.			
Saccoloma inaequale (Kunze) Mett.	Cunha 1269	H	TF/R
Schizaeaceae Kaulf.			
Schizaea elegans (Vahl) Sw.	Ribeiro 7844	H	TF/R
Tectariaceae Panigrahi			
Triplophyllum angustifolium Holttum	Sampaio 1279	H	R
Triplophyllum dicksonioides (Fée) Holttum	Sampaio 7319	H	R
Triplophyllum funestum (Kunze) Holttum	Zuquim 4883	H	TF
Thelypteridaceae Ching ex Pic. Serm			
Meniscium arborescens Humb. & Bonpl. ex Willd.	Ribeiro 7861	H	R

and the accumulation of organic matter, and presence of lichens and bryophytes (Nadkarni, 2000), however, no evidence of the use of herbicide was found in the area.

In ESEC Cuniã, *Lindsaea guianensis* (Aubl.) Dryand., *Didymoglosssum punctatum* (Poir.) Desv., *Selaginella asperula* Spring., *Salpichlaena hookeriana* (Kuntze) Alston., and *Trichomanes ankersii* C.Parker ex Hook. & Grev. are widely distributed along the entire grid, occurring in trails, *terra-firme* and riparian plots. Despite their wide distribution in ESEC, these species exhibit distinct environmental preferences in Amazonia. *D. punctatum* is found within the forest on trunks of living trees. *S. hookeriana* is a common species in open areas, such as margins of clearings, inland or at the edge of the forest, at the margin of igarapés (Prado, 2005c). *Mickelia guianensis* grows in understorey and canopy of dense forests (on nutrient rich soils) and in secondary forest areas. It develops in the soil and ascends towards the canopy using adjacent trees for support and can reach more than 10 m in height (Zuquim el al., 2008) *T. ankersii* grows in the dense forest understory, on soils with low to intermediate amount of nutrients is more common in plateaus or slopes, in sandy loam soils (Zuquim et al., 2008).

Some species stand out because they are restricted to a certain type of environment. *Phlegmariurus linifolius* (L.) B.Øllg. var. *jenmanii* (Underw. & F.E.Lloyd) B.Øllg., *Asplenium hallii* Hook., *A. stuebelianum* Hieron, *Didymoglossum angustifrons* Fée, *D. pinnatinervium* (Jenman) Pic. Serm., *Hymenophyllum polyanthos* (Sw.) Sw., *Cyathea microdonta* (Desv.) Domin., *C. pungens* (Willd.) Domin., *Mickelia guianensis* (Aubl.) R.C.Moran, Labiak & Sundue, *Danaea leprieurii* Kunze, *Campyloneurum repens* (Aubl.) C.Presl, *Microgramma reptans*, *M. megalophylla* (Desv.) de la Sota, *Adiantum obliquum* Willd., *A. terminatum* Kunze ex Miq., *Triplophyllum angustifolium* Holttum, *T. dicksonioides* (Fée) Holttum, *Meniscium arborescens* are from the riparian plots and *Asplenium angustum* Sw., *Elaphoglossum glabellum* J. Sm., *Trichomanes vittaria* DC. ex Poir., *Lindsaea lancea* var. *falcata* (Dryand.) Hieron, *Oleandra articulata* (Sw.) C.Presl., *Cochlidium linearifolium*, *Microgramma thurnii* (Baker) R.M.Tryon, *Adiantum tuomistoanum, Polytaenium guayanense* (Hieron.) Alston, *Triplophyllum funestum* (Kunze) Holttum are from t*erra-firme* plots.

The existence of exclusively riparian species is probably because certain species depend on shaded and extremely humid localities (Santiago et al., 2004; Maciel et al., 2007). According to Holttum (1938), intense luminosity limits establishment for many species. Riparian environments offer favourable conditions for the development of more sensitive plants, especially during early life cycle stages.

The present study highlights the need for more botanical collection and reporting in Rondônia state. The floristic diversity of ferns and lycophytes is certainly underestimated, considering the high number of new records found in a small area (25 km^2). These species were already known elsewhere in Brazilian Amazon and its occurrence in the Rondônia state were already anticipated. However, with limited botanical collecting, they had not previously been recorded. As ferns and lycophytes are sensitive to environmental changes, the knowledge of floristic diversity is important to support conservation planning in the area.

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DRYOPTERIS AFFINIS SUBSP. *CLUTHENSIS*: A NEW TAXON IN THE *DRYOPTERIS AFFINIS* COMPLEX (DRYOPTERIDACEAE)

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Key words: *Dryopteris affinis* complex, taxonomy, diploid, apogamy.

ABSTRACT

A new diploid taxon within the *Dryopteris affinis* complex is described from the Island of Arran, Scotland: *D. affinis* subsp. *cluthensis*. Its affinities are discussed and distinguishing features outlined.

INTRODUCTION

A distinct form within the *Dryopteris affinis* (Lowe) Fraser-Jenk. complex was recognised by the first author (A.R.C.) in Kingscross, Arran in 2014, and a crown was transplanted into cultivation for observation. Stace (2010) recognised four British species in the *D. affinis* complex: *D. affinis* with three subspecies, *D. borreri* (Newman) Newman ex Oberh. & Tavel, *D. cambrensis* (Fraser-Jenk.) Beitel & W.R.Buck with two subspecies, and *D. pseudodisjuncta* (Tavel ex Fraser-Jenk.) Fraser-Jenk.; this follows the classification published by Fraser-Jenkins in 2007. Superficially the new taxon appeared to have many of the characteristics of *D. cambrensis* subsp. *cambrensis* (Fraser-Jenk.), in particular the stalked innermost basiscopic pinnule, the pronounced dark spot spreading along the costa, the upward rotation of pinnae in relation to the rachis, and the twisting of the pinnules. In this latter regard it is also reminiscent of *D. affinis* subsp. *paleaceolobata* (T.Moore) Fraser-Jenk., which also shows the more pronounced basal lobing of the pinnules adjacent to and partially crossing the rachis. Spore and stomata size indicated the plant was probably diploid (cell size has been shown to be well correlated with ploidy in this and other fern taxa, e.g. Barrington, Paris & Ranker, 1986; Viane, 1985; 1988), and so further investigation was carried out. Fronds were sent to Guenther Zenner, who also observed that the macro-morphology suggested *D. cambrensis* subsp. *cambrensis,* whereas the micromorphology would suggest a diploid taxon, although differing in subtle but consistent ways from all of the currently recognised taxa. Flow cytometry was carried out at the University of Ghent by R.V. on fronds from two separate plants and this confirmed that both plants were diploid. Cytology of root tips by A.J.E. also confirmed that this is a diploid taxon. As a result of the distinctive morphology of this taxon, namely the long, stalked, lobed first basiscopic

pinnule, the pronounced spreading dark spot, and the basiscopic pinnule auricles covering the rachis, we here recognise it as a new subspecies of *D. affinis.*

MATERIALS

Material for study was collected from Arran, VC100, over a period of four years, as follows:

1. Plants from the type locality, Kingscross woodland: NS046287, 25/10/2015 (frond used for flow cytometry); NS045287, 16/11/2015; NS04622874, 25/11/2015; NS04592874, 25/11/2015; NS04572872, 12/02/2016 (crown collected for root tip examination); NS04603 28754, 12/07/2017 (Type specimen).
2. Plants from Sannox: NS01744580, 25/10/2015 (frond used for flow cytometry); NS01734580, 01/12/2018.
3. Plants from Lamlash: NS03803219, 01/12/2018; NS03783220, 25/06/2019; NS03783220, 25/06/2019.

METHODS

Fronds of the new taxon were collected by ARC for further examination, and two crowns from Kingscross were taken into cultivation, with permission of the land-owners. Photographic records were made of the plants in situ and also of the collected fronds.

Stipe length and width, lamina length, and length of the mid-frond pinnae of 16 fronds from 10 different plants were measured. Spore length in water, excluding the perispore, was measured, on early samples using available spores (c. 20), and on the type specimen using 100 spores at x 400 magnification. Strips of epidermis were placed in glycerine on a microscope slide, and the stomata measured at × 1,000 magnification, on early samples using 30 to 60 stomata, and on the type specimen and a cultivated crown, 100 stomata. Flow cytometry was carried out at the University of Ghent by R.V. on fronds from two separate plants. Fresh samples were chopped together with an internal standard (*Agave striata*), using a sharp razor blade, in a glass Petri dish containing nucleus isolation buffer (2.1% [w/v] citric acid monohydrate, 0.5% [w/v] Tween 20, distilled water). The nuclear suspension was stained with DAPI reagent [6.5% $NaH_2PO_4.2H_2O$, 40µl DAPI stock solution (5mg DAPI/ml)] in distilled water, in an amount of 1:4. The mixture was then filtered through a 50-µm nylon mesh and incubated for 10-20 min on ice. Samples were analysed using a flow cytometer (Ploidy Analyser, Partec GmbH, Münster, Gemany), following the supplier's instructions. To estimate the ploidy level results were compared with a database of cytologically checked specimens.

Chromosome counts were determined by A.J.E. Actively growing root tips from pot-grown plants were put into a solution of 0.002M 8-hydroxyquinoline for 24 hours in a refrigerator at 4°C. The root tips were then fixed using three parts absolute ethanol to one part glacial acetic acid and stored in a deep freeze until examination. The root tips were removed from the fixative and hydrolysed in 5N hydrochloric acid for 10 minutes, then placed into industrial methylated spirit, before being dabbed dry, and the terminal 3 mm of the root being removed and put into acetocarmine on a microscope slide. The root epidermis was removed under a dissecting microscope, and the meristem macerated. A cover slip was placed over the specimen, and the slide heated and 'squashed' according to the method of Manton (1950) for sporangia. Slides were examined and cells photographed using a Leica DM1000 microscope and Leica EC3 integrated camera.

RESULTS

Description of the new taxon

***Dryopteris affinis* (Lowe) Fraser-Jenk. subsp. *cluthensis* A.R.Church subsp. nova**. Type: A.R. Church (holotype BM; isotypes E, LIV), Kingscross shore woodland, eastern coast of the Isle of Arran, VC.100, Scotland. NS04603 28754. Collected 12th July 2017. BM collection numbers: BM001073703, BM001073704, BM001073705.

Differs from *D. affinis* subsp. *affinis* in the stalked innermost basiscopic pinnule and less leathery texture. Differs from *D. affinis* subsp. *paleaceolobata* in its triangular, less crimped pinnules, less dense, paler scales, and less glossy lamina. Similar to *Dryopteris cambrensis*, but differing in its diploid nature, with smaller spores (33-47µm) and stomata (40-50 µm).

The name commemorates its known distribution, Clutha being the Latin name for the Firth of Clyde on whose banks the plant was first discovered.

Terrestrial fern with erect rhizome, forming fairly robust, lax shuttlecocks with fronds up to 1.3 m; lamina bipinnate, a glossy mid- to deep-green; stipe c. 10 mm wide at base, about one-fifth the length of the frond, and less robust than that of *D. affinis* subsp. *affinis*, tending to bend and break as winter progresses.; stipe scales dense, narrow, pale- to mid-ginger brown with a darker base, and of two distinct sizes, the larger ones having a thin wispy tip about one-third the length of the scale, and the scale base being 4-5 mm wide (Figures 1-3); frond outline lanceolate, although lowest pinnae are equal to or not markedly shorter than those immediately above; mid-lamina width about one-third the length of the lamina (Figures 4, 5); lowest, innermost, basiscopic pinnule fully stalked, lobed, usually same length as the adjacent pinnule; very marked dark spot at the costa / rachis junction often extending along costa and into basiscopic pinnule; lowest pinnae broadly triangular; pinnae in mid-frond slightly lanceolate, after a slightly longer first pinnule (Table 1); pinnae rotated to face upwards, being held between 45 to 75 degrees to plane of frond; pinnules turned down at edges, with some in mid- to upper-frond angled away from the rachis; pinnules with rounded or gothic-arch shaped tips, sides lobed through most of the frond, though lobes shallow towards pinna ends, and may be obscured by turned-down pinnule edges. In some plants there is twisting of the pinnules in a similar manner but usually less so than in *D. cambrensis* and *D. affinis* subsp. *paleaceolobata*. Pinnule tips have a few rather blunt teeth, ≤ 90 degrees; veins distinct, nearly all reaching the margins of the pinnules (Figures 6,7). Indusia tucked under at edges, less sturdy than those of *D. affinis* subsp. *affinis,* and start to rise, shrivel, and turn upwards into flattened upturned cones after spores are shed, spores mostly good (c. 90%), length 40 (33-47) microns; stomata length 45 (40-50) microns; (Figures 8, 9). Spore length and stomatal length are consistent with diploid values, (Bizot 2015). Flow cytometry indicated that this is a diploid taxon, and this was confirmed by cytological examination of mitotic root tip cells which gave a count of 2n = 82 (Figure 10).

Tables 1 and 2 give the discriminating characteristics of *Dryopteris affinis* subsp. *cluthensis* in comparison with *D. affinis* subsp. *affinis, D. affinis* subsp. *paleaceolobata*, and *D. cambrensis* subsp. *cambrensis*. Typical forms are described in the tables, but there is variation within all these taxa, and less typical forms may be encountered.

DISTRIBUTION

It is currently known only on the Isle of Arran in the Firth of Clyde, Scotland where it has been detected in scattered localities on the east coast. Here it occurs generally as scattered individuals, or occasionally as small dispersed populations, in damp, often

Figure 1. *Dryopteris affinis* subsp. *cluthensis* whole plant, type locality, 25th November 2015

Figure 2. *Dryopteris affinis* subsp. *cluthensis* fronds, type locality, 9th February 2017

Figure 3. *Dryopteris affinis* subsp. *cluthensis* stipe scales, type locality, 12th July 2017

Figure 4. *Dryopteris affinis* subsp. *cluthensis* lower fronds, 25th August 2016

Figure 5. *Dryopteris affinis* subsp. *cluthensis* close up of lowest pinnae

Figure 6. *Dryopteris affinis* subsp. *cluthensis* mid frond

Figure 7. *Dryopteris affinis* subsp. *cluthensis* veins on lowest pinna

Figure 8. *Dryopteris affinis* subsp. *cluthensis* mature sori, type locality, 25th August 2016

Figure 9. *Dryopteris affinis* subsp. *cluthensis* indusia after spores shed, 25th November 2015

swampy coastal woodland and by small wooded streams and rivulets leading down onto the shore, at altitudes from c. 5-25 m a.s.l. The type locality of this plant is in the Ardlui shoreline woodland at Kingscross at NS04603 28754, in the south-east of Arran, Scotland, where there are more than 30 plants, growing with *D. cambrensis*. Several plants of the taxon have also been noted at Cordon, Isle of Arran, at NS0291 2994, again intermixed with *D. cambrensis*, and two plants at NS0380 3218 on a stream bank in Lamlash.

All the colonies found so far are on sedimentary sandstone of either Permian or Old Red Sandstone age. The sites are sheltered and damp, supporting the somewhat cryophobous and humidity-dependant *Dryopteris aemula* (Aiton) Kuntze and species of Hymenophyllaceae. With close proximity to coastal waters influenced by the Gulf Stream and with shade and other rocky micro-habitat features the sites are effectively frost-free. The soils are acid but there may be some basic influence and local nutrient enrichment.

DISCUSSION

Stace (2010) recognised four species in the *Dryopteris affinis* complex native to Britain, the three most common being the diploid *D. affinis* and the triploids *D. borreri* and *D. cambrensis*. A further triploid species, *D. pseudodisjuncta*, has only been recognised in Britain in the last decade, and published records are restricted to the south-west of Scotland, including the Isle of Arran. A further taxon, first found on Arran, has latterly been treated as a subspecies of *D. cambrensis*, as subsp. *pseudocomplexa* Fraser-Jenk.. There is ongoing debate as to how species should be defined in this apomictic complex (see for instance Rumsey, 2017). Sell and Murrell (2018) have raised the previous subspecies to the rank of species. Stace (2019) reverted to using one species with four subspecies. He, however, concedes that the practical alternative is a system, as adopted in angiosperm apomictic groups and advocated by Sell, where all variants are regarded as separate (agamo)species. Stace considered that at present knowledge was insufficient to effect such an approach, even though it was desirable. Sadly one consequence of lumping these taxa, in what has become the standard taxonomic guide of most field

Figure 10. Chromosomes in *Dryopteris affinis* subsp. *cluthensis* root tip squash.

Table 1. Photographic comparison of *Dryopteris affinis* subsp. *cluthensis* with *D. affinis* subsp. *affinis*, *D. affinis* subsp. *paleaceolobata*, and *D. cambrensis* subsp. *cambrensis*

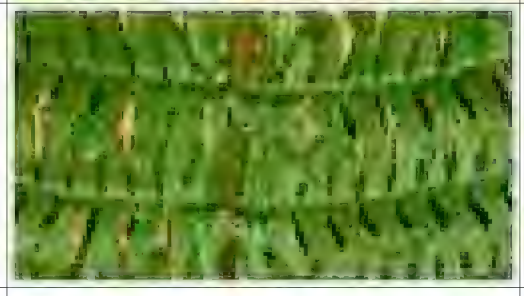
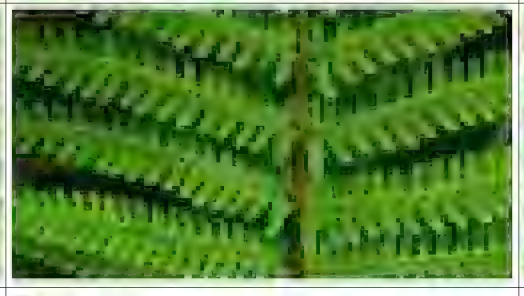
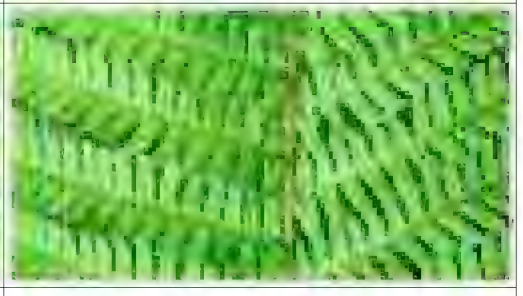
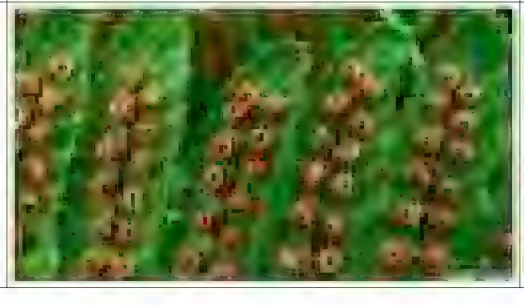
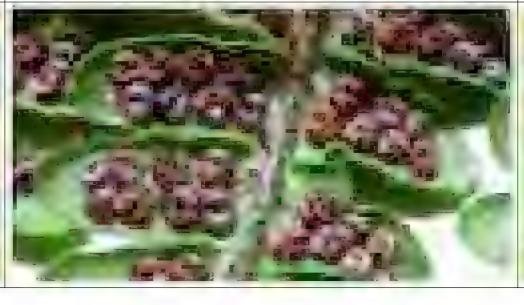
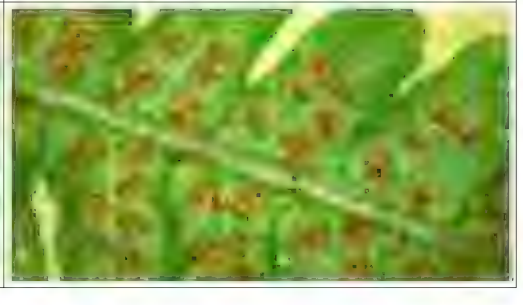
Feature	*Dryopteris affinis* subsp. *cluthensis*	*Dryopteris affinis* subsp. *affinis*	*Dryopteris affinis* subsp. *paleaceolobata*	*Dryopteris cambrensis* subsp. *cambrensis*
Lowest pinnae, middle section				
Mid-frond pinnae				
Single mid-frond pinna				
Mature sori				

Table 2. Comparative table of features of *Dryopteris affinis* subsp. *cluthensis*

Feature	***Dryopteris affinis* subsp. *cluthensis***	***Dryopteris affinis* subsp. *affinis***	***Dryopteris affinis* subsp. *paleaceolobata***	***Dryopteris cambrensis* subsp. *cambrensis***
Frond outline	Truncate at the base	Tapering to the base	Truncate at the base	Tapering to the base
Scales	Moderately dense, greyish-brown with dark base	Dense golden-brown	Dense, thin, dark reddish-brown	Dense, gingery-brown with dark base; stipe scales a mix of narrow and broad forms
Stipe	Less robust, tends to break in winter	Robust	Robust	Moderately robust
Lowest basiscopic pinnule	Stalked, deeply lobed, longer than acroscopic pinnule	Quarter to half adnate, not or barely lobed, slightly longer than acroscopic pinnule	Stalked, shallow to medium lobes, slightly longer to significantly longer than acroscopic pinnule	Stalked, rounded lobes, longer than acroscopic pinnule
Pinnules	Tapering to apex, marked rhomboidal lobes, convex, apex gothic or rounded arch, mostly blunt teeth	Mostly un-lobed, parallel sided, rounded-truncate apex, apical teeth obtuse	Parallel-sided, rounded side lobes, convex, pinnules often angled up and twisted away from the rachis, rounded or truncate apex, sometimes with flabellately-spread apical teeth	Convex, a crimped form with pinnules angled up and twisted away from the rachis, obtuse apical teeth.
Lamina	Bright green, moderately glossy	Yellowish to dark blue-green, very glossy and leathery	Start yellowish green and mature to glossy dark green	Bright, slightly yellowish green, somewhat glossy
Dark spot	Dark brown, extends to 2nd or 3rd pinnule	Less strong, hardly extends along costa	Blackish-brown, to 2nd or 3rd pinnule	Dark brown, extends to 2nd pinnule
Indusia after spores shed	Shrivel into upturned cones or butterly-wings	Rise and persist in ‘doughnut’ shape, radial splits	Radial splits, turning up into ‘butterfly wing’ appearance	May lift or form inverted cones, occasional radial splits. Thin margin.

botanists, will be to reduce detailed scrutiny and study, rendering the further clarification in this group less, not more, likely.

While the agamospecies approach is arguably the most logically consistent, the earlier approach adopted by Stace (2010) had merit in that its hierarchical nature better reflected relatedness, separating as it did at specific level taxa of different ploidies. Much, however, remains to be elucidated as to the precise genomic constitution and complex evolutionary histories of the distinct taxa and until these are clarified any such hierarchical system is open to criticism. In considering at what rank and under what species we wish to recognise this novel taxon we have been guided by pragmatism in our decision. We too, for now, follow the earlier approach adopted by Stace and therefore use the fact that this taxon is diploid to assign it at an infra-specific level to *Dryopteris affinis*. We suggest that this should be a sub-species rather than a variety or forma in line with the treatment of other taxa, showing as it does consistent distinct morphological features and a particular ecology and local distribution. We realise that in future further research into the genomic constitution of this taxon or broader changes to concepts and their application may result in it being re-assigned, probably as a separate species.

Although we expect that this taxon may in future be found in locations outside Arran, at present it is only known on Arran. In choosing a name we were aware of the previous use of 'morphotype Arranensis' (Pigott, 1997) for what is now known as *D. cambrensis* subsp. *pseudocomplexa* (Fraser-Jenk.), so although the epithet would be appropriate here, we felt it important to use a new name to reduce any risk of confusion.

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POLYPODIUM

CULTIVARS

and

SPECIES

by

Martin Rickard

British Pteridological Society

Special Publication No. 16

BOOK REVIEW

***Polypodium cultivars and species*. A review of all known cultivars and species worldwide. Rickard, M. 2019. Pp. vi + 320. British Pteridological Society Special Publication No. 16. Price £25.00.**

Polypodium has been a passion of the author over many years, and probably since he was first introduced to a fern. His interest has encompassed all aspects of the genus, from the worldwide distribution of the wild species, their recognition, taxonomic complexities and inter-relationships to the vast array of cultivars that have been recognised since some of the earliest collections. He has personally cultivated many of these species and cultivars, travelled widely to see plants in their native habitats, studied a wide range of historic and recent herbarium specimens, and corresponded extensively with many experts, thus gaining a unique understanding of the genus.

This book is his personal view of the genus. He deals very thoroughly with British and European cultivars – the wide array of diverse forms that have arisen from relatively few species, and this section will be of particular interest to the enthusiast. But the remaining third of the volume is devoted to descriptions of taxa from other continents, from North America, Hawaii, Asia, Australia and Africa, and here not only does he describe the species, their distributions and varieties, but provides an insight into some of the outstanding gaps in our knowledge. The book is profusely illustrated with many of his own colour photographs of plants in cultivation, or in the field, and with useful images of herbarium specimens.

Following a short taxonomic history of *Polypodium* in Chapter 1, he provides a list of taxa that he recognises and their distribution by geographic region. The focus is then on cultivars – their naming, the history of their discovery, information on past and present collectors, and detailed advice on cultivation. The following chapter deals with *Polypodium* in Europe, the identification and distribution of the taxa, and recognition of their hybrids. The next and longest chapter is devoted to cultivars of *Polypodium cambricum*, and here his love of the subject is fully expressed in the detailed description of each cultivar, the history of its discovery, his comments on their naming, and notes on cultivation etc. A shorter chapter describes the cultivars of *Polypodium interjectum*, *P. macaronesicum* and *P. vulgare*.

In describing polypods from the rest of the world, the author brings together information gleaned from the scientific literature and correspondence, with detailed descriptions, photographs, and personal knowledge gained from fieldwork and/or cultivation of material [and, of course, illustrates cultivars that have been recognised!]. For North America he usefully presents a series of five "major problem groups", and indicates areas where there are still gaps in our knowledge. For New Zealand, South Africa and Asia he illustrates some unusual morphologies of so-called *Polypodium vulgare* that appear to be crying out for more detailed research.

This book represents many years of serious scholarship that is written and illustrated in a very accessible style; it is a pleasure to dip into the book and discover some gems.

MARY GIBBY

This book can be purchased at: https://ebps.org.uk/publications/special-publications/

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×*PHLEBOSIA* (POLYPODIACEAE), A NEW FERN NOTHOGENUS WITH A NEW CULTIVAR 'NICOLAS DIAMOND'

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Key words: *Phlebodium*, *Pyrrosia*

ABSTRACT

In 2014 James J. Georgusis reported that a chance hybrid between *Phlebodium aureum* 'Mandaianum' and *Pyrrosia lingua* 'Cristata' had originated in his greenhouse in Metairie, Louisiana (USA). Though we initially were inclined to consider it a bizarre mutation of one of its putative progenitors, further study of its morphology and its nuclear 2C DNA content revealed it to be intermediate between its putative parents. We thus accept its proposed ancestry and hence describe this plant here in the new nothogenus ×*Phlebosia*.

INTRODUCTION

This article describes the discovery and research on an accidental and surprising hybrid between two (sub)tropical species, one from *Phlebodium* and the other a *Pyrrosia,* both belonging to the Polypodiaceae.

Direct crossings or hybrids between different fern species are not rare, but generally sterile (Reichstein, 1981). Usually, hybrids originate within a genus, and close relatives cross more easily. In the wild and within their own genus, sterile hybrids are formed between many fern species, but are best known and described in the northern temperate floras of Europe, North America, and Japan (Reichstein, 1981; 1984; Tutin et al., 1993; Iwatsuki et al., 1995). Because of their unbalanced genome, often a lack of homologous chromosomes, these primary hybrids (usually) cannot form viable spores and are sterile. However, disturbances during mitosis (Rasbach et al., 1991; Schneller, 1983) or meiosis may lead to a doubling of the number of chromosomes within a cell, a process usually referred to as "whole-genome duplication" or "polyploidisation". If this process occurs in a sterile hybrid, such a plant can create viable spores that could lead to a new self-reproducing population, reproductively isolated from its progenitors, i.e., a new species (e.g., Dauphin et al., 2017a; 2017b; Sigel, 2016). Hybrids are thus not always "dead ends" in evolution, but may be sources for new evolutionary lines as shown by extensive cytological research in the second half of the twentieth century (e.g., Lovis, 1977; Reichstein, 1981; Kramer et al., 1995; Sigel, 2016). About half of all European fern species are polyploid (Reichstein, 1981; 1984; Kramer, 1984, Kramer et al., 1995, Tutin et al. 1993), and just under half have arisen, sometimes even repeatedly, from a sterile cross between two (diploid) species (Schneller, 1996; Sessa et al., 2018; Vogel et al., 1999). Multiple origins of fern complexes were often postulated in the literature cited above and have now been demonstrated using molecular techniques (e.g., Soltis et al., 1987; Ranker et al., 1989; Schneller, 1996; Thomson & Alonso-Amelot, 2002; Beck et

al., 2012; Sigel et al., 2014; Sigel, 2016; Williams et al., 2016; Yahaya et al., 2016; Dauphin et al., 2017a; 2017b); similar evolutionary patterns are known from higher plants (Alix et al., 2017). Hybrids between species belonging to different genera are very rare (Alston, 1940; Reichstein, 1981; Schneller, 1981; Wagner et al., 1992; Rothfels et al. 2015; Engels & Canestraro, 2017; Lehtonen, 2018) and are ascribed to a nothogenus of their own. The existence of intergenetic hybrids often constitutes one of the arguments either to (re)unite relatively smaller genera, e.g., *Asplenium*, *Ceterach*, *Pleurosorus,* and *Phyllitis* to a single genus: *Asplenium* (Kramer & Viane, 1990), or to keep species within one and the same genus (Tejero-Diaz et al., 2009). According to Turland et al. (2018) a hybrid genus must be indicated by writing the symbol "×" before and without space against the generic name, e.g., ×*Asplenosorus*, ×*Dryostichum*, and ×*Pleopodium*. According to Brickell et al. (2016, art. 14.1) cultivar status has to be indicated by enclosing the cultivar epithet within single quotation marks.

In 2014, James J. Georgusis from Metairie, Louisiana, USA, found separate strange juvenile plants in his greenhouse, which he suspected to be the result of a spontaneous cross between the only two fern species he grew at the time: *Phlebodium aureum* 'Mandaianum' and *Pyrrosia lingua* 'Cristata' (Hoshizaki & Moran, 2001). From the hybrid sporelings he selected a single plant considered worthy of commercialization and to be introduced into the trade. The putative parents of the hybrid belong to different genera that may have been separated for at least 35 million years (Wei et al., 2017). Given the rather unlikely emergence of this hybrid, we first considered that it might be a bizarre mutation of one of its putative ancestors and thus sought to confirm its parentage.

MATERIAL AND METHODS

In 2015, the parent plants and their hybrid were delivered to the research department of the fern nursery "Vitro Plus, B.V.", located in Burgh-Haamstede (NL), with the intention to propagate the hybrid vegetatively. After two years, in 2017, enough material for further research had been obtained.

We studied the general morphology, the micro morphology of the leaf indument and rhizome scales, and the DNA quantity. Only fully-grown scales at a short distance from the apex were compared because they are often damaged on older parts. Because microscopic hairs on the rachis and the costae are often deciduous, or shrivel and become difficult to observe on older fronds of both *Phlebodium* and ×*Phlebosia*, their indument was studied on young, uncurling fiddleheads at a comparable stage. Unfortunately, no spore characterizations could be done because these were not available for *Pyrrosia lingua* 'Cristata', nor for ×*Phlebosia*, which at present remains sterile.

Sections of the rhizome, the rhizome scales, and the leaf hairs were photographed with a Canon MP-E 65mm f/2.8 1-5x Macro Photo lens on a Canon EOS 5DSR camera. Flow cytometry with propidium iodide (PI) staining was used to compare 2C DNA values (the content of DNA from the nucleus of vegetative cells). Nuclei were obtained from thin slices of the rhizome or the petiole finely chopped together with a comparable slice of *Agave* 'Shaka Zulu' (2C = 8.97 pg) as internal standard, and stained with the 'CyStain PI absolute P' nuclei extraction and staining kit (Partec GmbH, Münster) according to the manufacturer's instructions. Samples were analyzed with a Becton Dickinson BD Accuri™ C6 flow cytometer (Franklin Lakes, USA). At least 5,000 nuclei per sample were analysed, with five replicates per accession. The 2C value was calculated based on the ratios of the G1 peak means of the sample and the standard.

Terminology follows Stearn's *Botanical Latin* (1992) or Hoshizaki & Moran (2001).

RESULTS AND DISCUSSION

Numerical results, based on at least twenty measurements, are summarized in Table 1. Both the overall morphology and the size (see Table 1) of the hybrid are more or less intermediate between those of the putative parents, although the average values of the hybrid are shifted slightly more towards those of *Pyrrosia*. See Figures 1 to 3.

Rhizome

All plants have a widely creeping aboveground rhizome. The diameter of the rhizome of ×*Phlebosia* (4 to 8.5 mm) is intermediate between that of *Pyrrosia* (2.5 to 3.5 mm) and that of *Phlebodium* (10 to 20 mm; Table 1).

Rhizome scales

The rhizome of *Pyrrosia* carries appressed, narrowly triangular to lanceolate, rusty to golden brown, peltate scales (Fig. 2A), set apically and along the margin with extremely thin hairs (cilia sensu Hovenkamp, 1986). Scales on the rhizomes of *Phlebodium* and ×*Phlebosia* have a similar shape but lack the hairy apex (Fig. 2B-C) and are less appressed. The size of the rhizome scales of ×*Phlebosia* lies between that of the putative parents (Figure 2; Table 1).

Fronds

The mature leaf of ×*Phlebosia* is reasonably intermediate (somewhat more shifted towards *Pyrrosia*) between that of the suspected parents: it is clearly smaller (40 to 75 cm) than that of *Phlebodium* (115 to 135 cm) but much larger than that of *Pyrrosia* (19 to 32 cm). Furthermore, it is also pinnatipartite but not pinnatisect as in *Phlebodium*, medium to dark green, shiny and often laciniate or crested (cristate) at the apex of the frond and/or of its segments.

Frond surface

The characteristic stellate hairs of *Pyrrosia* (Figure 3D) are absent from the leaf surface of ×*Phlebosia*. However, we found microscales next to unicellular-to-multicellular glands (Figure 3, B-C) typical of prothallia and juvenile leaves of *Pyrrosia* (Nayar & Chandra 1965: 37; Hovenkamp 1986: 45), and not found in *Phlebodium*. These hairs are either

Figure 1. Rhizome cross sections (scales removed). A. *Pyrrosia* (R.Viane 14240); B. ×*Phlebosia* (R.Viane 14238); C. *Phlebodium* (R.Viane 14239*)* (scale bar: 10 mm).

Table 1. Summary of morphological characters studied.

	Pyrrosia			×*Phlebosia*			*Phlebodium*		
	min	Mean	max	Min	mean	max	min	mean	Max
Rhizome	creeping			creeping			creeping		
Rhizome ø (mm)	2.5	**3.2**	3.5	4.0	**6.9**	8.5	10.0	**15.4**	20.3
Scale length (mm)	3.9	**5.9**	8.9	6.2	**9.9**	11.0	12.9	**14.4**	15.0
Scale width (mm)	0.3	**0.7**	1.1	0.9	**1.0**	1.2	1.5	**2.0**	2.4
Stipe base ø (mm)	2.0	**2.4**	3.0	3.2	**3.6**	4.5	7.0	**8.0**	9.0
Stipe length (cm)	4	**6**	7	20	**28**	35	40	**46**	50
Lamina length (cm)	15	**20**	25	20	**33**	40	75	**80**	85
Lamina width (cm)	6	**9**	16	17	**22**	32	30	**32**	34
Frond length (cm)	19	**26**	32	40	**59**	75	115	**126**	135
Lamina/Stipe length	**3.3**			**1.1**			**1.7**		
Frond incision	simple to pinnatifid near the apex			pinnatipartite			pinnatipartite to almost pinnatisect		
Segment incision	—			laciniate to crested			laciniate to squarroso-laciniate		
Frond apex	acute or crested			crested			acute		
2C DNA (pg)	14.7	**15.2**	17.7	25.4	**26.3**	27.3	35.3	**38.0**	39.9

unicellular (c. 0.07 to 0.09 mm long), or 2 to 6-cellular and uniseriate, or 3-cellular and forked (Figure 3C) with individual cells usually less than 0.1 mm long.

DNA content

The 2C DNA content of ×*Phlebosia* is about intermediate (Table 1) between that of its putative parents.

Discussion and conclusion

Phlebodium aureum is an allotetraploid species (Walker, 1985; Tejero-Diez, 2009) with

Figure 2. Rhizome scales. A. *Pyrrosia* (R.Viane 14240), note hairs at apex; B. ×*Phlebosia* (R.Viane 14238); C. *Phlebodium* (R.Viane 14239) (scale bar: 2 mm).

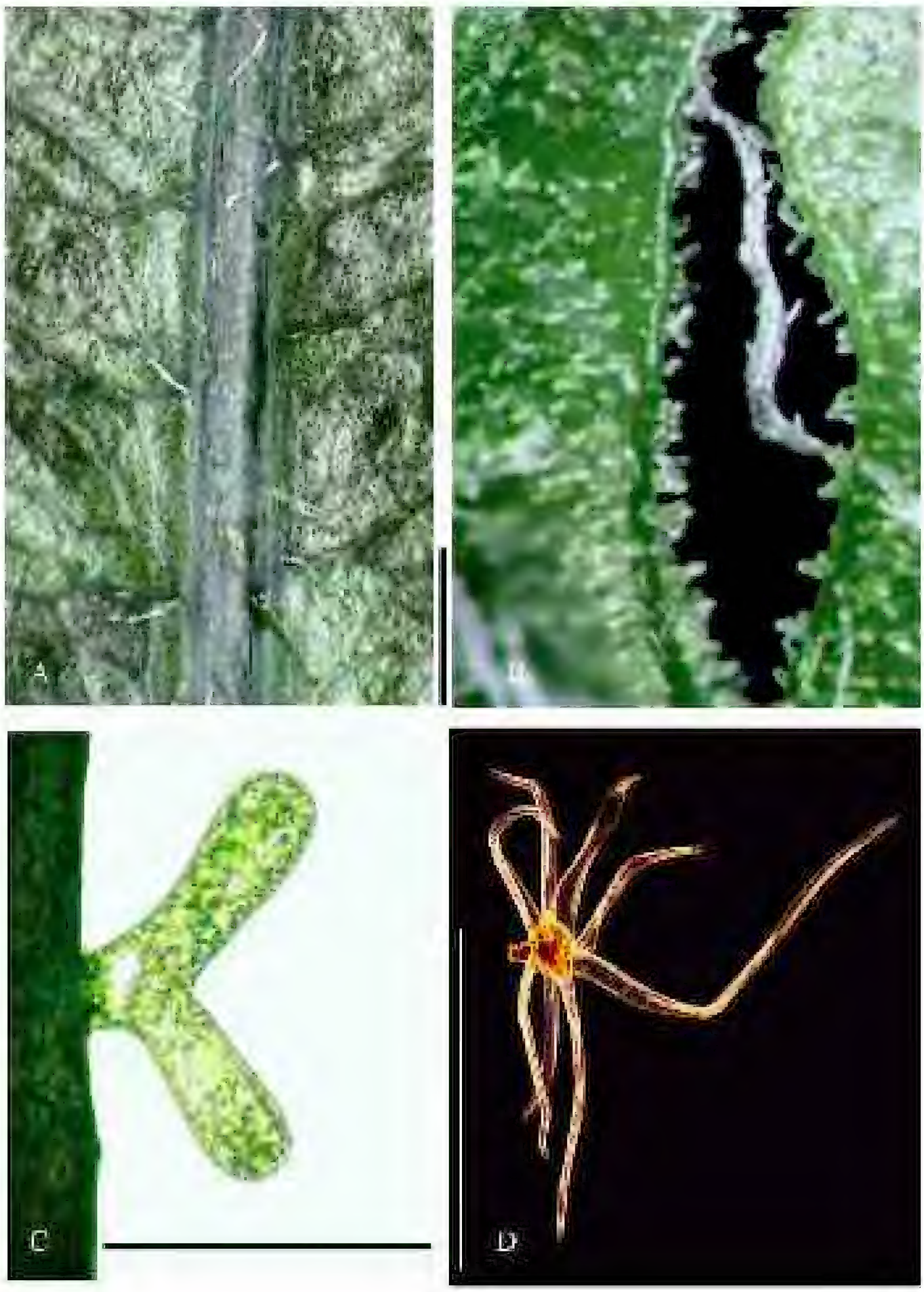

Figure 3. Lamina indument. A. *Phlebodium* (R.Viane 14239), sparsely hairy young leaf; B-C, ×*Phlebosia* (R.Viane 14238), densely hairy young leaf; C. central detail of B; D. stellate hair of *Pyrrosia* (R.Viane 14240), note short brownish stalk directed to left (scale bar: A, B, D: 0.5 mm; C: 0.1 mm).

2n=4x=148 chromosomes (e.g., Evans, 1963; Walker, 1985), while *Pyrrosia lingua* is diploid with 2n=2x=72 chromosomes (Takei, 1969 Wang et al., 2011), which is clearly manifested in the c. double DNA content of the first. In the putative hybrid we expected that half of the *Pyrrosia* genome (1C = 7.6 pg) would be united with half of the *Phlebodium* genome (1C = 19 pg) which would result in an average total weight of 2C= ~26.6 pg. The 2C DNA content found for ×*Phlebosia* fits well with this expectation (Table 1 and Figure 4). In *Pyrrosia*, both the basic chromosome number (x=36) and the basic DNA content (Cx = c. 7.6 pg) are different from those in *Phlebodium* (x = 37 and Cx = 9.5 pg).

Description

We first considered the possibility that the novelty might be a bizarre mutation of one of its putative ancestors. However, because its general and micromorphology, its size characters, as well as its nuclear 2C DNA content are about intermediate between those of its putative parents, we accept the ancestry proposed by the breeder and hence describe this plant here in the new nothogenus ×*Phlebosia*.

×*Phlebosia* Viane & Pompe, nothogen. nov. (*Phlebodium* J.Sm. × *Pyrrosia* Mirbel).

Genus hybridum inter *Phlebodium* J.Sm. et *Pyrrosiam* Mirbel intermedium.

Since other species from these genera could also form similar hybrids, the present hybrid between *Ph. aureum* and *P. lingua* is given a specific epithet referring to the state of Louisiana (USA) where it originated in cultivation.

×*Phlebosia louisiana* Viane & Pompe, nothosp. nov.

Hybrida inter *Phlebodium aureum* 'Mandaianum' et *Pyrrosiam linguam* 'Cristatam' plus

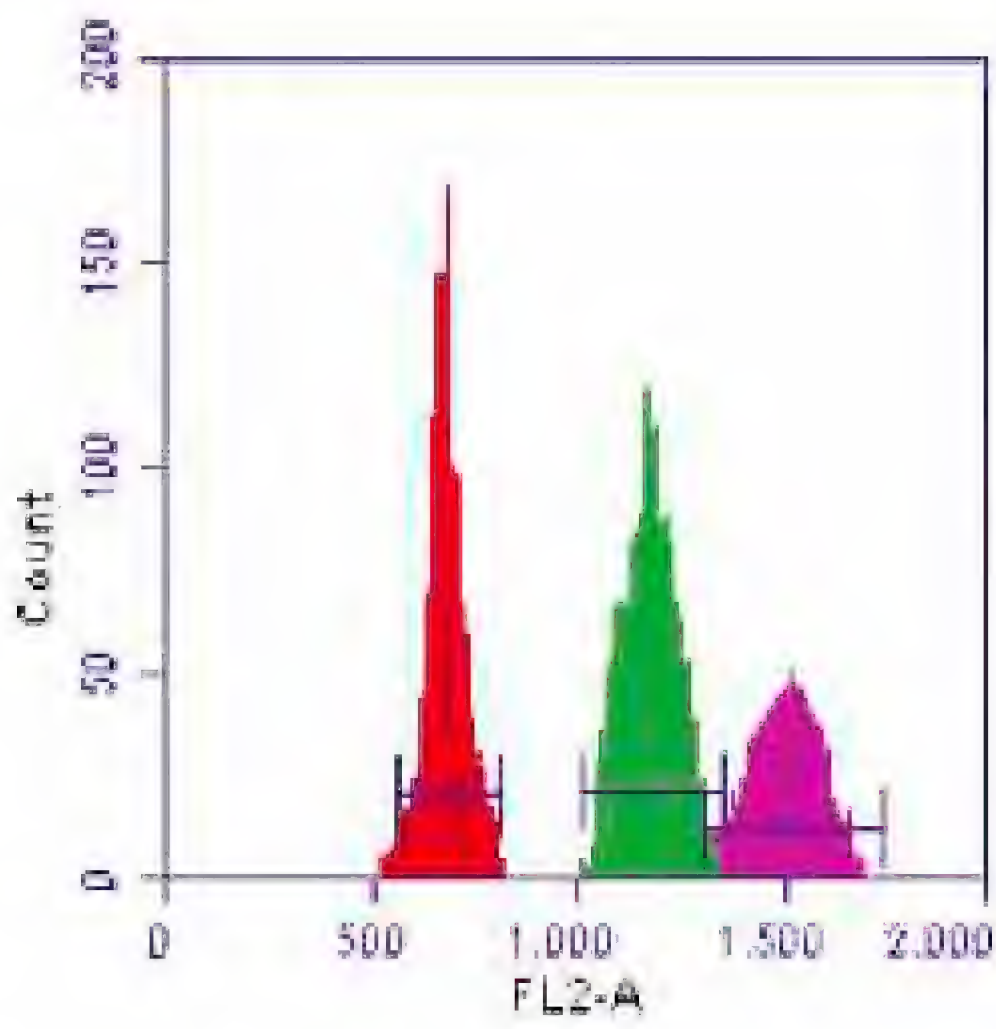

Figure 4. Flow histogram, with colours added, from combined leaves of *Pyrrosia lingua* 'Cristata' (red), ×*Phlebosia* (green), and *Phlebodium aureum* 'Mandaianum' (pink), following staining with propidium iodide. FL-2: propidium iodide fluorescent channel.

minusve intermedia.
Rhizome creeping, 4-9 mm in diameter, densely covered with imbricate, rusty to golden brown scales, 6-12 x 0.9-1.2 mm. Fronds erect to arching, 40-75 x 17-32 cm; stipes terete with a ventral groove, greenish to dark brown, 3-5 mm in diameter at the base, 20-35 cm long; uncurling lamina set with forked, multicellular hairs becoming subglabrous at maturity, lamina 20-40 x 17-32 cm, texture papery, dark green, brilliant, pinnatipartite; segments narrowly triangular, acuminate, often forked or crested at the apex. No fertile structures present yet on adult plant. DNA weight 2C=25.4 – 27.3 pg.
Type: herbarium material taken from progeny of the original hybrid of J.J. Georgusis (Metairie, New Orleans, Louisiana, USA), raised and multiplied by "Vitro Plus, B.V." (Burgh-Haamstede, NL), obtained by the author in 2019 for flow cytometric analysis, 2 July 2019, R. Viane 14238 (holo-: L; iso-: BM; P; pers. herb. R. Viane).
Progeny of the original hybrid between *Phlebodium aureum* 'Mandaianum' and *Pyrrosia lingua* 'Cristata' have been introduced into the trade as a new cultivar called 'Nicolas Diamond' (US plant patent: US 2019/01116710P1).
Specimens of the putative parents *Phlebodium aureum* 'Mandaianum' (R. Viane 14239) and *Phlebodium aureum* 'Mandaianum' (R. Viane 14240) will also be deposited in Leiden (L).

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EXTENDED DISTRIBUTION FOR A RARE FERN *TECTARIA MULTICAUDATA* IN PENINSULAR INDIA

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Keywords: Maharashtra, distribution, conservation status.

ABSTRACT

During revisionary work on the genus *Tectaria* from India, the authors came across an uncommon species collected at Panhala fort, Kolhapur District of Maharashtra state, India. After critical observation and detailed study of its morphology, it was identified as *T. multicaudata* which is a new distributional extension for peninsular India. Its distribution and conservation status are given along with a table of comparative morphology with allied species.

INTRODUCTION

Tectaria Cav. is one of the most diverse genera belonging to the family Tectariaceae[1], and was previously treated in the family Dryopteridaceae. About 200 species are accepted world-wide, of which 27 species (of which two are adventive) and one hybrid are recorded from India (Fraser-Jenkins et al., 2020). The diversity of pteridophytes in south India has been studied by many researchers (Beddome, 1883; Blatter & D'Almeida, 1922; Dixit, 1984; Mahabale, 1987; Manickam & Irudayaraj, 1992; Patil et al., 2009; Ding, 2013; Patil, 2014; Patil et al., 2019) and nine species of *Tectaria* had been reported for south India. Subsequently, Patil et al. (2014) collected *T. fuscipes* from different forest regions of Karnataka, determined by Fraser-Jenkins and reported it as a new distributional record for the Western Ghats and peninsular India. Later "*An Annotated Checklist of Indian Pteridophytes Part–2 (Woodsiaceae to Dryopteridaceae)*" was published by Fraser-Jenkins et al., (2018) and accepted the occurrence of *T. polymorpha* in south India whereas the occurrence of *T. fuscipes* in south India was omitted by mistake.

Recently an unexpected species of *Tectaria* was collected from Panhala Fort area, Maharashtra, and is identified here as *T. multicaudata* (C.B.Clarke) Ching. This species was previously known in India only from the North-East in the Eastern Himalaya. The present paper reports the extended distribution of *T. multicaudata* to western peninsular India.

Taxonomic description:

Tectaria multicaudata (C.B.Clarke) Ching, Sinensia 2: 20. 1931.
Holotype: Bangladesh, Sylhet, 250 ft., 30.11.1872, C.B. Clarke 18427C, K.
Plant terrestrial, large sized herb, c. 40–80 cm tall; *rhizome* thick, horizontal and creeping with leaves arising at the apex, scaly and with persistent leaf-bases; *scales* fuscous-brown, lanceolate, apex acuminate, base cordate-rounded, entire; *fronds* subdimorphic to dimorphic, fertile fronds having slightly narrower lobes and sterile ones with wider, laxer

lobes; *stipe* c. 20–45 cm, more or less length as the lamina, stout, fuscous-brown when mature, bearing dense, bicolorous scales at the base, extending to over two thirds of the stipe-length, becoming slightly smaller, narrower and gradually more scattered; *lamina* 15-25 cm long, sparsely scaly at young, deltate, yellow–green, bipinnate–tripinnatifid, sparsely hairy, bearing 5–7 pairs of pinnae, terminal 2–3 pinnae adnate, opposite–subopposite; pinnae bearing 10–15 adnate pairs of pinnules, apex long acuminate, herbaceous, pinnatipartite to broadly winged along costae and forming falcate–lanceolate lobes; *veins* anastomosing with or without included veinlets, costa and costules areole present without included veinlets; *sori* indusiate, in 2 rows; *indusia* changing from green to brown with age, large, rounded, membranous, entire, persistent (see Figure 1).

Distribution: World: Bangladesh, India, Malaysia, Myanmar, Nepal and Thailand.
India: Arunachal Pradesh, Assam, Maharashtra, Meghalaya and Sikkim.
Maharashtra: Kolhapur District.

Conservation Status: *T. multicaudata* is known so far only from a single locality at Panhala (Kolhapur District). A single population of about 10—20 individuals was found at the locality. Other forested areas of the state are yet to be explored thoroughly and more floristic explorations are needed to determine and document the full range of distribution in the State.

Specimens Examined: India, Maharashtra, Kolhapur Dt., Panhala, alt. 800 m, 13/08/2018. *S. M. Patil & K. S. Rajput* 3036, BARO; Tripura, North Tripura Dt., *Churaibari, alt. 600 m, 18/06/2011, A. Benniamin 28203, 22886, 26424, 14687,* ARUN.

DISCUSSION

Tectaria multicaudata has recently been segregated from the related *T. griffithii* (Baker).C.Chr. (Dong, et al., 2013) on the basis of frond type, stipe scales, pinnae phyllotaxy and venation. In *T. multicaudata* the fronds are not coarsely dissected; the stipe scaly up to rachis; it has opposite to subopposite phyllotaxy; and costal and costular areoles are present whereas in *T. griffithii* the fronds are coarsely dissected; the stipe scaly at the base only; it has alternate to-subopposite phyllotaxy; and costal and costular areoles are absent which differentiate the *T. multicaudata* and *T. griffithii*. The present authors agree with the species delimitation given by Dong et al. (2013).

We also observed that many herbarium specimens deposited in ARUN have costal and costular areoles and belong to *T. multicaudata*. It was also observed that many herbarium specimens deposited in ARUN, Itanagar have costal and costular areoles, hence all are treated as *T. multicaudata*.

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Figure 1. A. Habit of *Tectaria multicaudata,* B. venation pattern of *T. multicaudata,* C. venation pattern of *T. griffithii,* D. enlarged pinnae, E. photograph of herbarium specimen submitted by A. Benniamin to ARUN herbarium. Scale bar: C = 5 mm, D = 5 mm

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A PRELIMINARY STUDY OF PHYTOCHEMICALS IN *EQUISETUM ARVENSE* & *E. RAMOSISSIMUM* (EQUISETACEAE) EXTRACTS FROM NORTHERN IRAQ

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Keywords: Ferns, Flavonoids, *Equisetum*, phytochemicals

ABSTRACT

Plant extracts of *Equisetum arvense* and *E. ramosissimum* were investigated from the Chemi Rezan and Kalar regions in Sulaymaniyah/Iraq and Iranian foothills districts during the summer of 2016.

Qualitative analysis of methanol extracts indicated the presence of alkaloids, saponins, tannins and flavonoids. By using High Performance Liquid Chromatography (HPLC), the flavonoid content of two *Equisetum* species were analyzed, and may provide useful medicinal compounds. The presence of kaempferol, kaempferol-3-O-glycoside, leutolin and querctin were found in *E. arvense*, with total flavonoid content of 179.5 µg/ ml. The flavonoids kaempferol, kaempferol-3-O-glycoside, leutolin, myrcetin, querctin and rutin were detected in *E. ramosissimum* with a total flavonoid content of 831.8 µg/ml. This is the first documented study of *Equisetum* (horsetail ferns) extracts in Iraq.

INTRODUCTION

To date, there is no detailed comprehensive study on any species of ferns in the Kurdistan region of Northern Iraq (Maulood et al., 2016). All previous investigations on ferns in Iraq referred only to fern morphology and geographical distribution (Al-Mayah et al., 2016). The genus *Equisetum* is the only remaining representative of the once abundant and diverse class Equisetopsida (Pryer et al., 2001), and recent phylogenetic studies suggest that *Equisetum* should be classified within the true ferns (Pryer et al., 2001, Smith et al., 2006). *Equisetum* consists of 30 species of rush-like and jointed perennial herbs (Sandhu & Chopra, 2010). *Equisetum arvense* L. and *E. ramosissimum* Desf. (order: Equisetales, family: Equisetaceae) are members of a very primitive family of plants found in diverse habitats, such as open grasslands, along roadsides, railway tracks, swamps, wetlands and river banks (Maulood et al., 2016, Brownsey & Perrie, 2015). Many members of Equisetaceae have an important role in nutrient recycling and soil treatment

(Marsh et al., 2000). *Equisetum arvense* (field horsetail or scouring rush) belongs to subgenus *Equisetum*, recognised by its dimorphic aerial stems, sterile erect stems with undivided lateral branches arising in whorls, and fertile unbranched stems, occasionally producing terminal strobili in mid-summer. *Equisetum ramosissimum* (branched horsetail) belongs to subgenus Hippochaetae and is recognized by its unimorphic aerial stems, sterile and fertile branched stems, fertile stems and its branches producing strobili (Maulood et al., 2016). Spores in these two fern species are monomorphic, globose, green and bear four linear-spatulate elaters (Yatskiervych & Windham, 2008).

Many secondary metabolites (phytochemicals) have been shown to provide effective treatment to a wide variety of illnesses and ailments, and are being embraced by the public (Rajesh et al., 2014). Among these phytochemicals alkaloids, carotenoids and phenolics have been studied (Do Momtae et al., 2004) and have been used in the treatment of kidney and bladder disturbances in folk medicine (Briksin, 2000). *Equisetum telmateia* Ehrh. extracts have been used in traditional medicine for their anti-inflammatory and diuretic properites (Correia et al., 2005). Specifically, the ethyl acetate portion from HPLC showed strong antioxidant activity, with flavan-3-ol, kaempferol, and phenolic acid derivatives detected.

Recent investigations showed that the studied plants have anti-inflammatory, anti-microbial, anti-cancer and anticonvulsant effects (Radolovic et al., 2006). *Equisetum* species were reported to contain several flavonoids, alkaloids, phenolics, triterpenoids, saponins and phytosterols (Yatskiervych & Windham, 2008, Stajner et al., 2009). Flavonoids and phenolic acids are the most important groups of secondary metabolites and bioactive compounds in plants and good sources of natural antioxidants in human diets (Jain et al., 2016). *Equisetum arvense* extracts have also been found to have high antioxidant activity, especially in the ethyl acetate fraction. Specifically, among the phenolic compounds, isoquercitrin and di-E-caffeoyl-meso-tartaric were found in the fractions with high antioxidant activity (Mimica-Dukic et al., 2008).

Extracts of *E. arvense*, *E. sylvaticum* L., *E. fluviatile* L., *E. palustre* L. and *E. telmateia* Ehrh. were examined and assessed for antioxidant activity, phenol content and flavonoid profiles. The phenol content ranged from 92-349 μmol/g, with kaempferol-, quercetin- glycosides and caffeic acid derivatives identified as the major components, and *E. telmateia* showing the greatest antioxidant capacity (Milovanovic et al., 2007).

The goal of the present investigation is to quantify the flavonoid content in these *Equisetum* species in Iraq, which have not been studied in this region to date.

MATERIALS AND METHODS

Equisetum arvense and *E. ramosissimum* (Figure 1 A and B) samples were collected from Chemi Rezan and Kalar regions during summer of 2016. Dr. Ihsan Al-Shehbaz of Missouri Botanical Gardens identified the plant samples. Voucher samples (No. 4, 19, 5, *E. arvense* & No. 4, 19, 5, *E. ramosissimum* were deposited at the Howler Botanical Garden in the Erbil Governorate (Ismail, 2018). Geographical aspects of the study area are represented in Table 1.

The collected plants were brought to the laboratory and the aerial stems washed with tap water, followed by distilled water. The stems were then shade-dried at room temperature for 7-10 days and ground to a fine powder using an electrical grinder, and then the powdered samples were stored in an airtight container. A 10 g aliquot of plant powder was extracted with 100 ml of methanol (BDH) using a soxhlet apparatus and was decanted through filter paper (Whatman No.1). After filtration, the supernatant was

Table 1: Geographical characters of the study area

Regions	Chemi Rezan	Kalar
Elevation (m)	722	247
Longitude	34° 95. 050 N	34° 42. 821N
Latitude	39° 64. 065 E	045° 27. 867 E

further dried in a vacuum desiccator and then the dried extracts were stored in vials at 4°C. Phytochemical studies of the dried extracts was performed in the Biotech research laboratory, College of Science for Women, University of Baghdad. The detection of active compounds in plant materials was performed following a standard procedure (Harborne, 1998). To test for alkaloids, 1 ml plant methanolic extract was added to 2 ml Mayer's reagent. The turbidity or precipitation of green colour was observed, indicating the presence of alkaloids. To test for flavonoids, 3 ml plant methanolic extract was mixed with 4 ml 1N NaOH in a test tube, and the formation of dark yellow colour was observed, indicating the presence of flavonoids. To test for saponins, plant extract weighing 0.5 g was dissolved in 3 ml boiling distilled water in a test tube, allowed to cool and shaken well to mix thoroughly, where the appearance of foam indicates the presence of saponins.

Figure 1. A. *Equisetum arvense*, B. *E. ramossisimum*, collected from Chemi Rezan and Kalar regions north of Iraq.

Table 2. The retention time and the area of standard flavonoids

No.	Compounds	Retention time (min)	Area
1	Quercetin	1.25	67880
2	Routine	2.54	98186
3	Luteolin	3.47	114892
4	Kaempferol	4.37	109560
5	Kaempferol-3-O-glycosid	5.29	107439
6	Myricetin	6.20	75818

To test for tannins, plant extract weighing 0.5 g was boiled in 20 ml distilled water and then filtered and 1 ml filtrate plant extract was mixed with 5% $FeCl_3$ (1 ml). The appearance of brownish green colour indicates the presence of tannins.

HPLC was used for quantitative analysis following standard procedure from Suarez et al., 2005. The dried methanolic extract was dissolved in 1 ml HPLC methanol after being filtered through Millipore filter paper (pore diameter 0.45µm), and 20µl of filtrate extract injected into HPLC instrument by an auto sampler according to the optimum conditions. The main compounds were separated on FLC column: C18-DB, 3µm particle size (50 x 2 mm ID) column, mobile phase: linear gradient of solvent A 0.05% trifluoracetic acid in deionized water: solvent B was 0.05% TFA in methanol pH 2.4 gradient program from 0 % to 100 % for 10 minutes. Flow rate 1.1 ml /min. Detection: UV at 280 nm.

Calculation: concentration of sample µg/ ml = area of sample/area of standard x concentration of standard x dilution factor.

The separation occurred on liquid chromatography Shimadzu 10 AV – LC equipped with binary delivery pump model LC – 10A. The eluted peaks were monitored by UV-Vis spectrophotometer. The retention time and the area of standard flavonoids are presented in Table 2.

RESULTS

Phytochemical screening:

The qualitative analysis of methanolic extracts showed the presence of alkaloids, saponins, tannins and flavonoids in *E. arvense* and *E. ramosissimum*, Table 3.

HPLC analysis:

The results of quantitative analysis of methanol extracts showed the flavonoids concentrations in *E. arvense* and *E. ramosissimum*, given in Table 4. The qualitative study of methanol plants extracts of *E. arvense* and *E. ramosissimum* showed the presence of four groups bioactive compounds: saponins, tanins, alkaloids and flavonoids (Table 4). The results of phytochemical screening in these two species are in accord with the reported studies in true fernesh et al., 2014; Asgarpanah & Elnaz, 2012; Hoque et al., 2016).

The results of HPLC analysis of fern extracts was revealed in the presence of the four flavonoids kaempferol, kaempferol-3-o- glycoside, leutolin and querectin in *E. arvense* and the six flavonoids kaempferol, kaempferol-3-o- glycoside, leutolin, myrcetin,

Table 3. Qualitative analysis of phytochemicals in plants

Plants	*E. arvense*	*E. ramossisimum*
Alkaloids	+	+
Flavonoids	+	+
Tannins	+	+
Saponins	+	+

quercetin and rutin in *E. ramosissimum* (Table 4). Leutolin was recorded in the highest concentration (100.6 µg/ml) *in E. arvense* but myrcetin had the highest concentration (223.5 µg/ml) in *E. ramosissimum* (Table 4). The results showed a higher concentration of total flavonoid (831.8 µg/ml) in *E. ramosissimum* compared with the concentration of total flavonoid (179.5µg/ml) in *E. arvense* (Table 4).

DISCUSSION

The high concentration of total flavonoids in *E. ramosissimum* from Kalar region may indicate a key role in protecting the plant against environmental stresses especially abiotic conditions such as high temperature (Borges et al., 2013). Phenolic and other active compounds act as a chemical interface between plants and environment (Gobbo-Neto & Lopez, 2007). Flavonoids not only participate in protection against harmful abiotic factors, but also allow interactions with other organisms (plants, animals and microorganisms) and their reactions to environmental stresses (Mierziek et al., 2014). Concentrations of phenolic compounds like flavonoids can be influenced by environment changes and there was a positive correlation between the phenolic compound's concentration and the environmental stresses (Monterio et al., 2006). It has been reported that flavonoids also directly interact with biological membranes, reducing their fluidity and making them more resistant to many oxidative factors (Harborne & Williams, 2000). The changes in the concentrations of chemical contents may be used as criterion in estimating the degree of stresses and plant responses to environmental factors. However, such changes in flavonoid concentrations can affect directly the quality of the fern for medicinal use (Al-Khasreji et al., 2017).

Table 4. Quantitative analysis of flavonoids (µg/ ml) in plants

Plants	*E. arvense*	*E. ramosissimum*
Quercetin	9.9	121.6
Rutin	-----	93.8
Kaempferol	26.6	177.6
Kaempferol_3_o_glycoside	42.4	145
Luteolin	100.6	70.3
Myracetin	-----	223.5
TotalFlavonoids	179.5	831.8

Absent: (-----)

CONCLUSIONS

The current study revealed that there are several bioactive compounds into two investigated *Equisetum* species. The investigation gathered information about the quantitative of flavonoids to provide the basis for future clinical trials and other medicinal research.

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THE GENUS *OPHIOGLOSSUM* (OPHIOGLOSSACEAE) IN WEST BENGAL, INDIA

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ABSTRACT

The genus *Ophioglossum* has been studied to make a list of the species occurring in West Bengal, India, along with their distribution patterns in the State. In the present investigation we have found that *Ophioglossum* is represented in West Bengal by five or six species, *O. costatum*, *O. gramineum*, *O. parvifolium*, *O. pendulum*, *O. petiolatum* and *O. reticulatum. Ophioglossum pendulum*, if present, and *O. petiolatum* are restricted to the northern part of West Bengal whereas *O. gramineum* typically occurs in the southern part. *Ophioglossum costatum*, *O. parvifolium* and *O. reticulatum* are distributed throughout the State.

INTRODUCTION

Ophioglossum L., the type genus of family Ophioglossaceae, was described by Linnaeus (1753) in *Species Plantarum*. *Ophioglossum vulgatum* L. is the lectogeneritype (chosen by John Smith, Hist. Fil. 367. 1875). There has been considerable confusion regarding the number of species in the genus, but estimates vary from 42-52.

Clausen (1938a) treated nine species and three varieties of *Ophioglossum* from India, followed by Mahabale (1962), who treated 10 species; Wieffering (1964), in a less accurate work, treated only four species and two forms from India (and erroneously synonymised *O. petiolatum* within *O. reticulatum*); Panigrahi & Dixit (1969) and Dixit (1984) treated 11 species and four further varieties; while Goswami (1987; 2007) estimated 12 species and four varieties; Fraser-Jenkins (2008) treated nine species and excluded *O. vulgatum* and *O. nudicaule* as being extra-Indian. Recently Fraser-Jenkins et al. (2016; 2018; 2020) accepted 12 species of *Ophioglossum* in India, though Goswami, Patel and others treat more, including various new species from peninsular India.

Indian species accepted by Fraser-Jenkins et al. are: *O. costatum* R.Br., *O. eliminatum* Khand. & Goswami, *O. gomezianum* Welw. ex A.Braun apud Kuhn, *O. gramineum* Willd., *O. lancifolium* C.Presl (tentative identification), *O. lusoafricanum* Welw. ex Prantl, *O. parvifolium* Grev. & Hook., *O. pendulum* L., *O. petiolatum* Hook., *O. polyphyllum* A.Braun ex Seub., *O. reticulatum* L. and *Ophioglossum rubellum* Welw. ex A. Braun. He excluded *O. vulgatum* L., *O. nudicaule* L.f., *O. thermale* Kom. and *O. lusitanicum* L. as being extra-Indian, represented in India by different species, and now

partly tentatively synonymises eight recently described species from India, *O. oleosum* Khand., *O. indicum* B.L.Yadav & Goswami, *O. raphaelianum* Anto et al., *O. malviae* M.Patel & M.N.Reddy, *O. gujaratense* S.M.Patil et al., *O. hitkishorei* M.Patel & M.N.Reddy, *O. aletum* M.Patel et al. and *O. chaloneri* Goswami et al.. These synonymised species all occur in the Western Ghats of peninsular India and are not relevant to West Bengal, several are under further study by their authors and final numbers accepted for India may change later. At present the estimated number of species in India varies from 12 to 20 according to different authors.

Ghosh et al. (2004) listed seven species and two varieties from N.E. India, of which five species and one variety were listed as present in West Bengal, but their nomenclature, identification and taxonomy were often inaccurate and confused and they did not provide a reliable account.

West Bengal is one of the largest states of India, extending from Darjeeling in the north, situated in the East Central Indo-Himalayan ranges, to the Sunderbans in the south, on the coast of the Bay of Bengal. The mountainous region of the north is cool almost all the year around and is dominated by coniferous forest. By contrast, in the Sunderbans at near sea-level the soil is saline and the vegetation is predominantly warm tropical mangrove swamp. The plains of West Bengal are also very diverse as regards edaphic and prevailing climatic factors. The districts of Bankura and Purulia have lateritic soil and the climate is hot for most of the year. These regions are dominated by forests of *Shorea robusta* Gaertn.f. According to Manna and Roy (2014), it is possible to detect populations of *Ophioglossum* species by identifying plant-associations that are characteristic for them. They showed that some species of angiosperms are associated with *Ophioglossum* whereas other species of angiosperms have negative association.

The species of *Ophioglossum* occurring in West Bengal have not so far been reliably documented and as the region is representative of much of northern India for this genus, we have attempted to list them and show their distribution-patterns in the State.

MATERIALS AND METHODS

Field survey was carried out in a number of localities in West Bengal and the specimens collected were processed in the laboratory for preparation of herbarium specimens. One set of specimens has been deposited in the Central National Herbarium, Botanical Survey of India, Howrah (Kolkata), West Bengal (CAL), and another set was deposited in the Department of Botany, Burdwan Raj College, Bardhaman, West Bengal (BRCH). Identification of specimens was done by reference to literature, including Beddome (1883), Ghosh et al. (2004), and Fraser-Jenkins et al. (2015; 2016) and also by reference to the digital herbarium of the Royal Botanic Garden, Kew, England. Some of our identifications were confirmed by Dr. Pushpesh Joshi of the Botanical Survey of India, Northern Regional Centre, Dehradun, India, and others were identified by Mr. C.R. Fraser-Jenkins, Cascais, Portugal. We have also studied the holdings of *Ophioglossum* from West Bengal etc. at CAL.

From these studies we have listed the species of *Ophioglossum* growing in West Bengal with their diagnostic features and places of occurrence. Their distribution patterns are shown in the map of West Bengal below (Figure 1).

TAXONOMIC TREATMENT

Key to West Bengal *Ophioglossum* species

It is important in *Ophioglossum* to study a number of specimens in the population to

understand the range of variation in shape and size. A single specimen on a herbarium-sheet can often be difficult to recognise and identify.

1) Plants epiphytic ..... *Ophioglossum pendulum*
1) Plant terrestrial 2
  2) Rhizome globose, roots thin, sterile blade often with a slightly paler median band ..... *Ophioglossum costatum*
  2) Rhizome cylindrical, erect, roots slightly fleshy, sterile blade never with a paler median band 3
    3) Trophophyll linear ..... *Ophioglossum gramineum*
    3) Trophophyll lanceolate to ovate 4
      4) Sporangia five to eight pairs per spike ..... *Ophioglossum parvifolium*
      4) Sporangia more than eight pairs per spike 5
        5) Trophophyll cordate or truncate at base ..... *Ophioglossum reticulatum*
        5) Trophophyll elliptic, narrowed to base ..... *Ophioglossum petiolatum*

1. ***Ophioglossum costatum*** R.Br., Prodr. Fl. Nov. Holland. 163. 1810.

Ophioglossum pedunculosum Desv., Mag. Neuesten Entdeck. Gesammten Naturk. Ges. Naturf. Berlin 5: 306. 1811.

Ophioglossum fibrosum Schumach., Beskr. Guin. Pl. 452. 1827.

Ophioglossum wightii Grev. & Hook., Bot. Misc. 3: 218. 1833.

Ophioglossum vulgatum L. var. *costatum* (R.Br.) Hook.f., Fl. Nov.-Zeland. 2(2): 50. 1854.

Ophioglossum brevipes Bedd., Ferns S. India 23, t. 72. 1863.

Plants 8.0-25.0 cm long; rhizome globose or spherical bearing many thin, yellow-brown

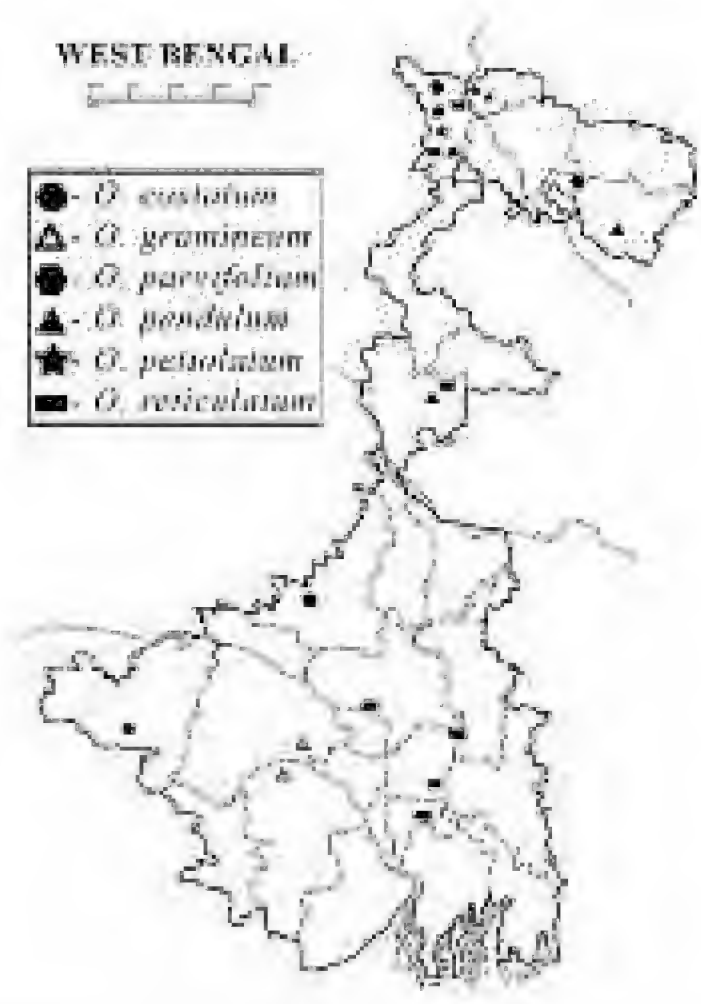

Figure 1: Map of West Bengal showing the distribution of different species of *Ophioglossum*

fibrous roots, without stolons or proliferous buds; common stalk up to 4.0 cm long; trophophylls 1-4, 2.5-12.0 × 1.0-2.7 cm, elliptic-lanceolate, sometimes ovate or obovate, acute or obtuse, herbaceous, often with a prominent median band of veins, primary veins forming large, oblong to hexagonal areoles in which are included networks of secondary veinlets forming smaller secondary areoles; fertile stalk 3.0-18.0 cm long; spike 1.0-6.0 × 0.25-0.4 cm with no sterile tip, sporangia 20-30 in each of the two rows; spores 20-40 µm in diameter, trilete, finely reticulate (Figure 2A).

Collections: Darjeeling Distr., Sikkim, *T. T*[*homson*]. 2841 spec. 833, 1857, BM (suspected to be mislocalisation); Purulia Distr. (formerly Manbhum), Purulia, *Revd. J. Campbell* 27171, 12.5.1951, CAL.

Distribution in West Bengal: Darjeeling, Purulia.

As with most earlier collections, Campbell's specimen was identified tentatively as *O. vulgatum*, but was reidentified as *O. fibrosum* by H.L. Chakravarty, 12.5.1951, later confirmed as *O. costatum* by J. H. Weiffering as in 1963.

2. ***Ophioglossum gramineum*** Willd., Abhandl. Kurf.-Mainz. Akad. Nütz. Wiss. Erfurt 2(6): 18, t. 1, f. 1. 1802.

Ophioglossum vulgatum L. var. *gramineum* (Willd) Hook.f., Fl. Nov.-Zeland. 2(2): 50. 1854.

Ophioglossum prantlii C.Chr., Index fil. 471. 1906.

Ophioglossum gramineum var. *majus* (Alderw.) Wieff., Blumea 12(2): 324. 1964.

Plants 4.0-12.0 cm long; rhizome cylindrical, erect, with few, slightly fleshy roots running obliquely downward; common stalk up to 3.5 cm long; trophophylls 1-3, 1.0-3.0 × 0.13-0.3 cm, linear, grass-like, ascending, acute, herbaceous with 2-3 parallel veins; fertile stalk 1.5-3.5 cm long; spike 0.5-2.5 x 0.1-0.3 cm with a very small sterile tip, strobili bearing 5-10 pairs of sporangia arranged in 2 alternate rows, pale-green to yellow; spores 25-40 µm in diameter, trilete, broadly reticulate (Figure 2B).

Collections: Paschim Medinipur [Midnapore] Distr., Mondolpuskarini, Garbeta, *R.H.N. Chaudhuri*, 8.1975, no details about deposition (Chaudhuri & Pal, 1979); Bankura Distr., Joypur Forest, *A.B. De* BUR1908, 8.2019, BRCH.

Distribution in West Bengal: Bankura, Paschim Medinipur.

We did not find any West Bengal specimens of this species in CAL, but we collected this inconspicuous and often overlooked species at Joypur Forest, Bankura. In West Bengal, *O. gramineum* was first collected from Mondolpuskarini, Garbeta in the district of Midnapur (now Paschim Medinipur) in August, 1975 as *O. gramineum* var. *gramineum* (Chaudhury & Pal, 1979), but they did not provide any details about deposition of their collected specimen.

3. ***Ophioglossum parvifolium*** Grev. & Hook., Bot. Misc. 3: 218. 1833.

Ophioglossum macrorrhizum Kunze, Analect. Pteridogr. 2. 1837.

Ophioglossum schmidii Kunze, Linnaea 24: 246. 1851.

Ophioglossum vulgatum L. var. *macrorrhizum* (Kunze) Luerss., J. Mus. Godeffroy 3: 242-244. 1875.

Ophioglossum pumilum (Racib.) Alderw., Malayan Ferns, Suppl. 1: 453. 1916.

Ophioglossum nudicaule var. *macrorrhizum* (Kunze) R.T.Clausen, Mem. Torrey Bot. Club 19(2): 150. 1938.

Ophioglossum nudicaule var. *tenerum* (Mett. ex Prantl) R.T.Clausen, Mem. Torrey Bot. Club 19: 146. 1938.

Plants occasionally up to 10 cm long, usually less; rhizome cylindrical with a few downward or sideways-directed fleshy roots, which often bear proliferous buds; common stalk up to 1.5 cm long; trophophylls 1-3, 0.4-1.0 × 0.3-0.8 cm, ovate-lanceolate, acute, slightly succulent-herbaceous with simple reticulate venation; fertile stalk 2.0-5.0 cm long; spike 0.5-1.7 × 0.1-0.2 cm with a very small sterile tip, strobili bearing 5-8 pairs

Figure 2: A. *Ophioglossum costatum* Purulia, *Revd. J. Campbell* 27171, CAL; B. *Ophioglossum gramineum* Joypur Forest, *A.B. De* BUR1908, BRCH; C. *Ophioglossum parvifolium* Kachujore Forest, Suri, *R.K. Basak* s.n., CAL; D. *Ophioglossum pendulum* Perak, Malaya, *L. Wray* 1133, CAL; E. *Ophioglossum petiolatum* Sureil, 5200 ft., Darjeeling, *D.D. Prain* 27195, s.d., CAL; F. *Ophioglossum reticulatum* Burdwan Univ. Campus, Bardhaman, *S. Jash* & *A.B. De* BUR1912, BRCH.

of sporangia arranged alternately in 2 rows; spores 30-45 μm in diameter, trilete, coarsely reticulate (Figure 2C).

Collections: Darjeeling Distr., Rungeet, [below] Darjeeling, 2000 ft., C.B. Clarke 27160, 22.8.1875, K (sub "O. vulgatum?", part reidentified by F. Ballard as *O. nudicaule* var. *tenerum*); Birbhum Distr., Kachujore Forest, near Suri, *R.K. Basak* s.n., CAL.

Distribution in West Bengal: Birbhum, Cooch Behar (Chowdhury *et al.*, 2016), Darjeeling.

Ophioglossum parvifolium was formerly included, along with other small species, within reports from India of *O. nudicaule*, but that species is now understood to be endemic to South Africa and is not present in India. Basak (1968) reported this species from Birbhum under the name *O. nudicaule* var. *macrorrhizum*. Chowdhury et al. (2016) also reported *O. nudicaule* from the Duars [Dooars] foothills in Cooch Behar District, but no details or description were given and they did not indicate if any specimen was collected. The identity of this record cannot be confirmed, but if they had not misapplied the name to *O. petiolatum* or *O. reticulatum*, it should presumably have referred to the present species.

4. ***Ophioglossum pendulum*** L., Sp. Pl., ed. 2, 2: 1518. 1763.

Ophiderma pendula (L.) C.Presl, Suppl. Tent. Pterid. 56. 1845.

Plants epiphytic; rhizome small, white, creeping, bearing many fleshy roots; 1-6 fronds arising close together directly from rhizome, trophophylls up to 200 cm long and 0.6-9.0 cm wide, ribbon-like, pendulous,, narrowed towards the base, often one or more times furcated, apex acute or obtuse, texture thin, flaccid-succulent, veins forming a series of long narrow areoles, clearly visible in dried specimen; fertile branch single, rarely two, borne from the middle of the width of the lamina, 6.0-45.0 cm long and 0.5-1.5 cm wide, about 200 sporangia arranged in 2 rows; spores triangular, rarely circular, 40-50 μm in diameter, trilete, smooth (Figure 2D).

Collections: We have not seen any collections from West Bengal and there is only one report by Sanyal et al. (2012) from Cooch Behar, Darjeeling and Malda, listed without specimen citation.

Distribution in West Bengal: Doubtfully from Cooch Bihar, Darjeeling and Malda.

Ophioglossum pendulum is an epiphytic species, known from Sikkim State, Assam State, Arunachal Pradesh, Kerala and the Andaman Islands (Fraser-Jenkins et al., 2016), but previously unknown from West Bengal. There are no West Bengal specimens in international or Indian herbaria and no reports apart from by Sanyal et al. (2012). We have reason to doubt their report as their list contains many errors and lists numerous species known only from further east in N.E. India, but not West Bengal. As no further details were given, nor even the name of the compiler, we could not investigate or confirm this unlikely report.

5. ***Ophioglossum petiolatum*** Hook., Exot. Fl. 1: 56, t. 56. 1823.

Ophioglossum moluccanum Schltdl., Adumbr. Fil. Prom. Bon. Spei 9. 1825.

Ophioglossum vulgatum L. var. *australasiaticum* Luerss., J. Mus. Godeffroy 3: 246, t. 13, 15. 1875.

Ophioglossum reticulatum L. var. *complicatum* (Miq.) Wieff., Blumea 12(2): 330. 1964.

Plants 10.0-20.0 cm long; rhizome short, erect, cylindrical, slender, bearing several fleshy roots, which often bear proliferous buds; common stalk up to 6.0 cm long, whitish at base; trophophylls 1-3, up to 6.0 cm long and 3.0 cm wide, but usually smaller, shortly

petiolate, elliptical or lanceolate, acute at apex, base gradually narrowed, slightly succulent-herbaceous, with reticulate venation, veins anastomosing, 6-10 veins forming basal midvein-like structure; fertile branch 5.0-10.0 cm long; spike up to 5.0×0.5 cm with a small sterile tip, sporangia up to 30 pairs, arranged alternately in 2 rows; spores 30-45 µm in diameter, trilete, somewhat coarsely reticulate (Figure 2E).

Collections: Darjeeling Distr., "[British] Sikkim", Goke ("Goak"), 4000 ft., *T. Anderson, M.D.* 1409, 15.6.1862, K, CAL; Darjeeling Distr., "Sikkim Himalaya", Teesta, *G. King* s.n., 25.2.1876, K, CAL; Darjeeling Distr., "Sikkim", Sureil, 5200 ft., *D.D. Prain* 27195, s.d., CAL; Darjeeling Distr., Kalimpong, 4000 ft., *E.A.C.L.E. Schelpe* 3669, 9.8.1952, BM; Darjeeling Distr., Tiger Hill, 8500 ft., *S.C. Verma* 201, 8.1956, PAN (62, 201), sub *O. vulgatum*, redet. C.R. Fraser-Jenkins as *O. petiolatum*; Darjeeling Distr., Senchal Forest, 8000 ft., *S.C. Verma* (as "Versima" in error) 3, 24.8.1956, K; Darjeeling Distr., Senchal Forest (Chaudhuri & Sarkar, 2003); Kalimpong Distr., Youth Hostel Bungalow Compound, 1200 m, *S.R. Ghosh* 57687, 7.1983, CAL.

Distribution in West Bengal: Darjeeling, Kalimpong.

Ophioglossum petiolatum has been much confused with *O. reticulatum* due to the variability in frond-shape of the latter, which can have narrower leaves with less obvious abrupt narrowing to their bases and is often then confused with *O. petiolatum*. Most of the reports of *O. vulgatum* from India apply to *O. petiolatum*, or otherwise to *O. reticulatum*. *O. petiolatum* was incorrectly synonymised into *O. reticulatum* by Wieffering (1964). It was reported to grow on moist sandy, alluvial soil among grasses and mosses from 600-2400 m altitude by Ghosh *et al.* (2004). Ghosh and Majumdar (2018) have mentioned the occurrence of *O. petiolatum* in Bhadreswar and reported for first time from Hooghly district. But they did not provide any description of specimen as well as any details about deposition. So it can be concluded as a doubtful record.

6. ***Ophioglossum reticulatum*** L., Sp. Pl. 2: 1063. 1753.

Ophioglossum cordifolium Roxb., in Griffith, Calcutta J. Nat. Hist. 4: 475. 1844.

Ophioglossum cognatum C.Presl, Suppl. Tent. Pterid. 53. 1845.

Ophioglossum vulgatum L. var. *reticulatum* (L.) D.C.Eaton, Mem. Amer. Acad. Art. Sci., n. s., 8: 218. 1861.

Plants up to 30 cm long; rhizome cylindrical, erect, bearing a few long, thick, fleshy, unbranched roots, which often bear proliferous buds; common stalk 4.0-10.0 cm long, dark green; trophophylls 1 or 2, rarely 3, up to 10 cm long and 4 cm wide, broadly ovate or cordate, sometimes elongated and parallel-sided when among thicker vegetation, usually obtusely pointed apically, widest towards the base which narrows abruptly to the petiole, base truncate to often cordate, succulent herbaceous, with strongly reticulate venation; fertile segment up to 15 cm long; strobilus up to 5.0 × 1.0 cm, without any sterile tip, sporangia 20-42 pairs, arranged alternately in 2 rows; spores 30-45 µm in diameter, trilete, finely reticulate (Figure 2F).

Collections: Hooghly Distr., Bengal, Nemora Bengalia, *W. Roxburgh* s.n., 1808, in Wallich Num. list no. 47.1 pp., K-W, K, US, BM; Howrah Distr., inter mangiferas, in H[ort.] B[ot.] C[alcutta], *N. Wallich* Num. List no. 47.1 pp., 9.1825, K-W and 10.1817, BM, UC; Hooghly Distr., Serampores, [*N. Wallich*], herb. Hookerianum, K; Bengalia, *N. Wallich* s.n., 1829, herb. Hookerianum, K; Hooghly Distr., Serampore, *W. Griffith* s.n., s.d., BM; ditto, *Dr. Lemann* s.n., s.d., BM; Darjeeling Distr., Darjeeling, *W. Griffith* s.n., s.d., herb. Hookerianum, K; Calcutta, *A.W. Helfer* s.n., K; Darjeeling Distr., Tukvar, in garden soil, [*T. Anderson* s.n.], 16.9.1857, CAL; Darjeeling Distr., Darjeeling, *R.H.*

Beddome s.n., s.d. K; Darjeeling Distr., Observatory Hill, Darjeeling, 7160 ft., *H.C. Levinge* s.n., 6.1880, K, CAL (det. as *O. reticulatum* by C.B. Clarke and by Dr. Pushpesh Joshi); Lower Bengal, Howrah Distr., wild in H[ort]. B[ot]. C[alcutta], in grass by the side of the Oreodoxa Avenue, *Mr. Davies* s.n., 1.8.1896, CAL; Malda Distr., Hatimari, *R.M. Dutta* 480, 24.8.1966, CAL; Hooghly Distr., Balagarh, Guptipara, *S. Deb* 133, 8.2014, KAL (Deb et al., 2018); Purba Bardhaman Distr., Burdwan University Campus, Golapbag, *S. Jash* & *A.B. De* BUR 1912, 2.2019, BRCH.

Distribution in West Bengal: Darjeeling, Hooghly, Howrah, Malda and Purba Bardhaman.

Most of the older specimens were originally misidentified as *O. vulgatum*, which was the name usually used by earlier botanists before the species of *Ophioglossum* in India became better known. Clausen (1938b) cited *O. cognatum*, described from Calcutta (*A.W. Helfer*), as a synonym of *O. petiolatum*, but with its ovate frond and rounded base it was more likely to be a specimen of *O. reticulatum* with a thicker midrib, than usual. The presence of endophytic bacteria in the roots of *O. reticulatum* from Darjeeling was documented by Mukherjee *et al.* (2017).

DISCUSSION

Ophioglossum is a difficult genus with much variation within the species, not only in sterile blade shape (particularly in *O. reticulatum* and *O. petiolatum*), but also in size. Populations of small, almost dwarf specimens can occur in those two species, which can create confusion with *O. parvifolium*, for example, and has also led to description of unwarranted new species in peninsular India. In addition most species have been found to contain more than one cytotype so that cytology alone is not a determinator of specific identity. Although spore-ornamentation is an important and useful means of differentiation of some species, it is also subject to some variation within species. It is therefore necessary to combine all these different aspects when identifying collections, even though trophophyll morphology remains the most useful guide. Many collections are not sufficient for definite identification due to having insufficient material on the sheet to be able to understand the degree of variation, one or two specimens only in herbarium-specimens or in illustrations in publications may not be sufficient and as long as it does not cause too much damage to the population, it is better to collect a reasonable number of specimens to help with accurate determination.

Chhetri et al. (2005) reported *O. vulgatum* from Darjeeling at 1500-2400 m, but they did not study ferns in detail. Their report should be either *O. petiolatum* or *O. reticulatum*, but we have not seen their collection for further identification.

We have excluded *O. lusitanicum* from West Bengal. West Bengal was listed in the distribution of this species by Patil & Dongare (2014) and Kachhiyapatel et al. (2018), but no-one has specified a collection or place of occurrence in West Bengal. As this species was not detected by us during our surveys and we have seen no specimens in herbaria or precise reports in literature, we exclude it from West Bengal pending further investigation.

From the present investigation we have found that *Ophioglossum* in West Bengal is represented by five or six species out of an average of 14 species reported from India. These are *O. costatum*, *O. gramineum*, *O. parvifolium*, ?*O. pendulum*, *O. petiolatum* and *O. reticulatum*, and have been found to grow in 11 out of the total 23 Districts of West Bengal. The distribution-pattern of these species is of interest as it may be related to the phytogeographical relationships of the species concerned, not only their local habitat and

climate requirements. If really present, *O. pendulum* is apparently restricted to the northern part of West Bengal, whereas *O. gramineum* occurs only in the southern part, as currently known. *Ophioglossum costatum*, *O. parvifolium* and *O. reticulatum* grow in both north and south. The distribution of *O. petiolatum* may also be is confined to the north and at slightly higher altitude than the others, but this record is not yet verified; we suspect Clausen's report of it from Kolkata could be merely a less characteristically wide-based specimen of *O. reticulatum*, although we have not seen the specimens. Subsequent collecting activity and comparative studies on the genus could perhaps reveal the possible presence of further species in West Bengal and should certainly reveal further localities of occurrence.

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NEW FERN RECORDS FOR THE STATE OF MORELOS, MEXICO: *HEMIONITIS PINNATIFIDA* AND *MYRIOPTERIS LONGIPILA* SUBSP. *BREVIPILA* (PTERIDACEAE)

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ABSTRACT

We report two new records of rare fern species for the state of Morelos, Mexico: *Hemionitis pinnatifida* and *Myriopteris longipila* subsp. *brevipila*. For both species, we describe their main characteristics, cite studied material and present photographs and distribution maps, followed by comments on their habitat characteristics, historical record, rarity, and differential characteristics to closely related species or varieties.

INTRODUCTION

Ferns represent 4.4% of the vascular flora of Mexico (Tejero-Díez et al., 2014) and 5.6% of Morelos (188 taxa) (Riba et al., 1996; Hernández-Cárdenas et al., 2014), a Mexican state located in the southern, central highlands covering an area of nearly 5000 km^2. Several authors have studied the fern diversity of Morelos (Vázquez-Sánchez, 1974; Riba et al., 1996; Bonilla-Barbosa & Villaseñor-Ríos, 2003; Mickel & Smith, 2004; Bonilla-Barbosa et al., 2010; Sánchez-Popoca, 2016), yet most collection efforts have focused on angiosperms (Riba, 1998). Here, we report on two new records of rare fern species for the state of Morelos that were documented during a botanical survey of the Sierra de Huautla Biosphere Reserve (SHBR), where ferns currently represent 6% (57 species) of the recorded vascular plants (Sánchez-Popoca, 2016).

METHODS

Between 2014 and 2017, three botanical surveys were carried out in the Huautla Biosphere Reserve, located in southern Morelos. This reserve comprises an area of 59.030 ha, representing nearly 12% of the state of Morelos, and extends across an altitudinal range from 670 to 2200 m. The dominant vegetation is classified as tropical dry forest (Dorado et al., 2005). First, we reviewed the literature records of all fern species of the state of Morelos (Vázquez-Sánchez, 1974; Riba et al., 1996; Bonilla-Barbosa & Villaseñor-Ríos, 2003; Mickel & Smith, 2004; Bonilla-Barbosa et al., 2010). Then, we identified the collected specimens and corroborated their identity

with material from the National Herbarium of the National Autonomous University of Mexico (MEXU), the Metropolitan Autonomous University (UAMIZ), as well as with specimens in online databases such as TROPICOS (2019) and Boyle et al. (2013), and help of other specialists (Aniceto Mendoza Ruíz). The classification used in the present study was that of PPG I (2016). Based on the collected information, we elaborated distribution maps for each species. Finally, the collected specimens were deposited in the herbarium of the Center for Biodiversity and Conservation Research of the Autonomous University of the State of Morelos (HUMO).

RESULTS AND DISCUSSION

Hemionitis pinnatifida Baker *in* Hooker & Baker, Syn. Fil. 399. 1868. Type: Costa Rica: Wendland 438 [holotype: K].

Species description. Plant herbaceous, terrestrial; Rhizomes ascending to erect, with linear scales, bicolorous with dark brown central portion and light brown margins, 4–5 x 0.8 mm. Fronds clustered, dimorphic, 5–20 cm long; Stipes 1–2 mm diameter, terete, castaneous, with narrow scales at bases, hirsute, the hairs glandular, 0.1 mm long; Blades pinnatifid palmately lobed, 4–10 cm long, margins crenulate, adaxial and abaxial surfaces with dense, articulated, acicular hairs of 1–1.5 mm long; Veins netted; Sori along all veins; Indusia absent; Spores light yellow-orange.

Studied material. MEXICO. Chiapas, to 38 km north east to Motozintla, Cuauhtémoc City, glen in holm oak forest, 750 m.a.s.l., 22/10/1985, *Breedlove 38432* (MEXU), *Lionnet 2663* (MEXU), *Matuda 2128* (MEXU). Ciudad de México, *Montoya 19* (MO). Guerrero, *González 344* (FCME), along the Barranca Choloa highway, municipality of Chilpancingo, riparian vegetation in rocky soil, 29/09/1988, *Verduzco-Martínez 401* (ENCB). Jalisco, Huehuenton highway to 20–25 km east to Chamela, municipality of Huerta, on slopes and in tropical subdeciduous forest, very few individuals, 400 m.a.s.l., 27/08/1976, *Rzedowski & McVaugh 1361* (ENCB). Morelos, along the Huautla-Santiopa highway, Tlaquiltenango, 1018 m.a.s.l., 18°26'43.4"N, 98°59'18.7"W, terrestrial, in tropical dry forest, 9/05/2014, *A.D. Sánchez-Popoca 223* (HUMO) (Figure 1A, B; Figure 2). Oaxaca, *Campos 4659, Lyons 103, 141* (MEXU), *Sánchez 221* (MEXU).

Comments: *Hemionitis pinnatifida* is terrestrial and grows from 50 to 2700 m elevation in Mexico (ENCB, HUMO, MEXU, UAMIZ): Chiapas, Oaxaca, Guerrero and Jalisco, and also occurs in Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica (Tropicos, 2019). In 2016, the population in the study area was composed of six fertile individuals, of which we collected two individuals. No gametophytes and young sporophytes were found within a range of 50 m distance. The area was covered by Leptosol soil (INEGI, 2017). The population of the collected specimens was exposed to direct sunlight, but was surrounded by trees of *Conzattia multiflora* (Robinson) Standl. (Fabaceae) and *Guazuma ulmifolia* Lam. (Malvaceae), which were both dominant. The only other herbaceous vegetation consisted of *Selaginella pallescens* (C. Presl) Spring and *Cheilanthes brachypus* Kunze. Visits performed later in 2017 confirmed that the population had been extirpated as a result of the expansion of the federal highway. For this reason, the collected individuals and photographs are important given that they present the only recent historic record of *H. pinnatifida* in the state of Morelos.

Hemionitis pinnatifida can be confused with *H. palmata* L., a species with a much

wider distribution throughout the Neotropics. However, the first species has a denser indumentum of hairs, and bicolorous rhizome scales (vs. concolorous in *H. palmata*).

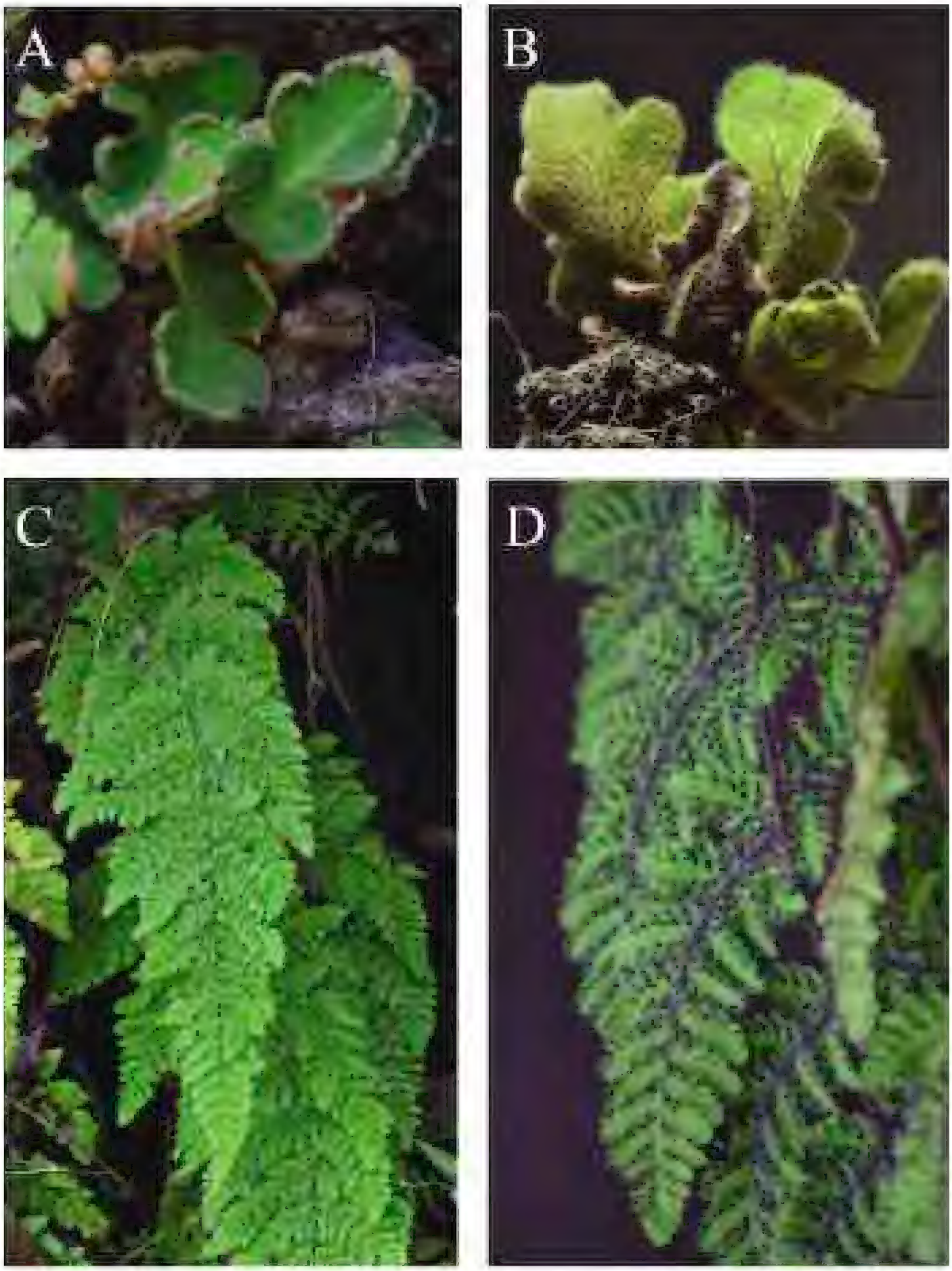

Figure 1. A, B. *Hemionitis pinnatifida* Baker. C, D. *Myriopteris longipila* subsp. *brevipila* (Mickel) Grusz & Windham. A, C. Species habit. B, D. Abaxial surface of fertile frond

Figure 2. Geographic distribution of *Hemionitis pinnatifida* Baker based on herbarium records.

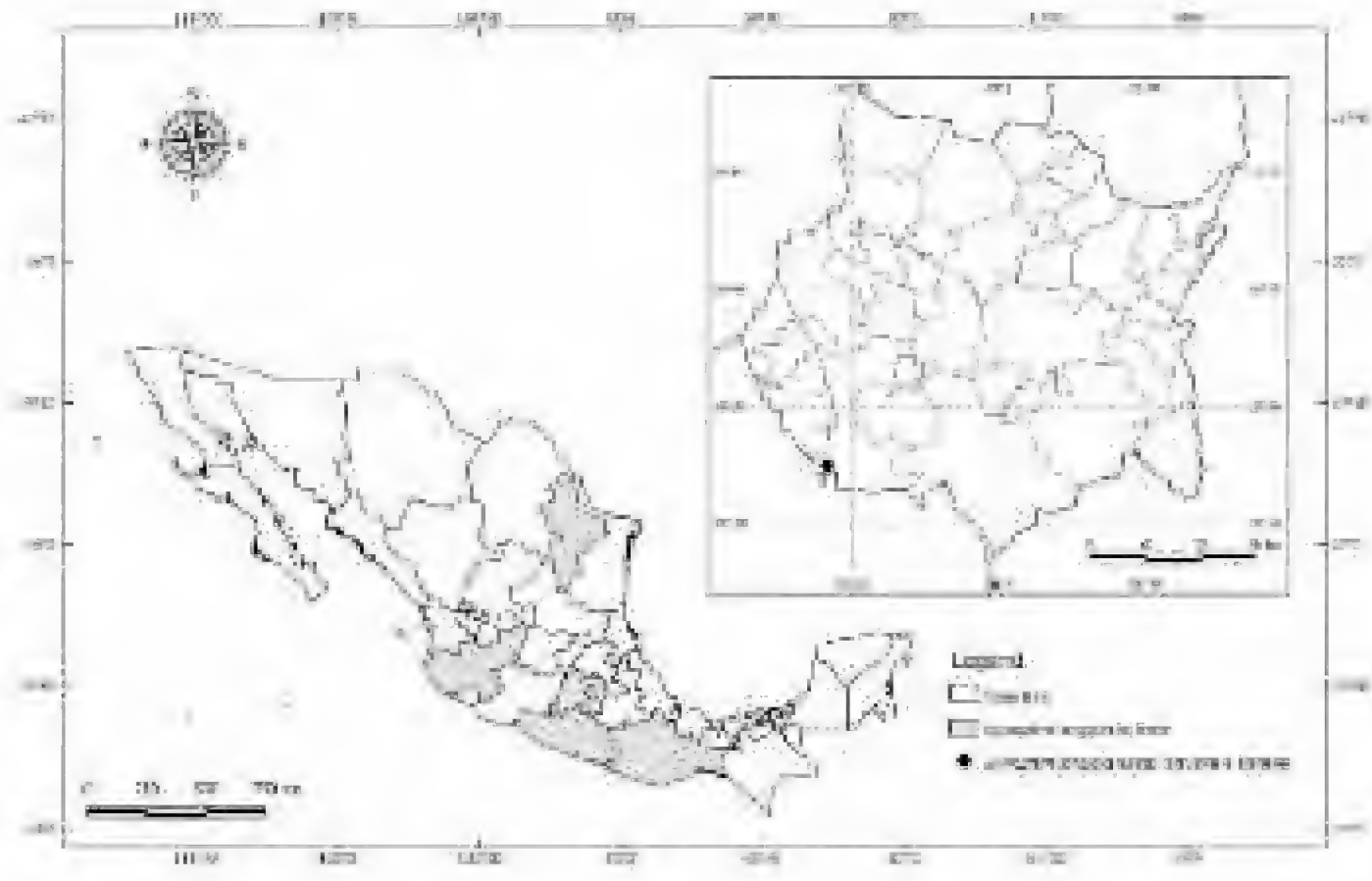

Figure 3. Geographic distribution of *Myriopteris longipila* subsp. *brevipila* (Mickel) Grusz & Windham based on herbarium records.

Myriopteris longipila subsp. *brevipila* (Mickel) Grusz & Windham, Bot. (Oxford) 5: 211. 1891. Type: Mexico. San Luis Potosí, 22°N Lat., 6000–8000 ft., Parry & Palmer 989 [holotype: K; isotype: US (fragment)]. Basionym: *Cheilanthes longipila* subsp. *brevipila* Mickel

Species description. Plant herbaceous, terrestrial; Rhizomes erect covered with adnate scales, irregular, concolorous, golden to castaneous, margins irregular. Fronds clustered, laxly arching; Stipes terete or grooved, brown, lustrous, 10 cm long, 1.5 mm diam, covered with dense, flexuous, septate, glandular hairs, 1.5–2 mm long, scales at bases concolorous, golden, patent, lanceolate, clathrate, but marginal cells light brown, scale margins entire, 2–5 mm x 1–2 mm; Rachises terete, lustrous, castaneous, covered with dense, septate, patent, glandular hairs, 1–2 mm long; Blades lanceolate, 3- or 4-pinnate at bases but less divided at the apices, up to 22 cm long, pinnae 2–10 x 1–5 cm, pinnules 1–2 x 6–8 mm; adaxial surface with dense, septate, hyaline, patent hairs, abaxial surface with dense, simple to septate, entangled, hyaline, hairs; Veins obscure. Sori exindusiate, marginal on the veins; Spores varying from dark to light brown

Studied material. MEXICO. Guerrero, to 2km south east of Amatitlán, 1600 m.a.s.l., 13/08/1994, *Antonio 339* (FCME, NY), *Calzada 16172* (NY). Morelos, along the El Zapote-Los Tanques highway, Puente de Ixtla, 1300 m.a.s.l., 18°29'24.2"N, 99°20'32.3"W, terrestrial, 19/10/2014, *A.D. Sánchez-Popoca 318* (HUMO) (Figure 1C and D; Figure 3).

Comments: This subspecies is endemic to Mexico where it occurs from 600 to 2200 m elevation (ENCB, HUMO, MEXU, UAMIZ). Mickel & Smith (2004) described its habitat as rocky slopes in oak forest or tropical dry forest on volcanic soil. The population in the study area consisted of only five fertile plants within a 50 m radius. The underlying soil was Phaeozem (INEGI, 2017).

The present record of the subspecies is only the third collection for Mexico. Mickel & Smith (2004) referred to *Myriopteris longipila* as *Cheilanthes longipila* Baker and distinguished two varieties: *C. longipila* var. *longipila* and var. *brevipila.* The former is distinguished from the latter by hairs 1–3 mm long (vs. 0.5–1 mm) in length on the adaxial surface and 1 mm (vs. 0.5 mm) on the abaxial surface, flexuose, stipe with trichomes 0.5–2 mm (vs. 0.2–0.5 mm, occasionally 1 mm). The characteristics of the latter variety match those of our collected specimen.

CONCLUSION

According to Arreguín-Sánchez *et al.* (2009), species that have not been collected for more than 25 years are rare and those that have not been collected for more than 50 years may be locally extirpated. Based on our study, both studied species must be considered as rare, because *H. pinnatifida* has been recorded 12 times since 1972 (in the last 45 years), and *Myriopteris longipila* with two subspecies has been recorded 10 times since 1939 (in the last 78 years). In the future, the conservation status of both taxa should be evaluated at the national level given their limited distribution and endemic status of *M. longipila* subsp. *brevipila*.

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PAPERS should not usually exceed 20 printed pages and are generally expected to be considerably shorter. As well as reports of original research, review articles and short notes, e.g. new records, are encouraged. The senior author should supply an email address to facilitate correspondence.
REVIEWS should cover recent developments in any aspect of research on ferns and lycopods. This can include unpublished research by the author, and/or the possible direction of future research. They should be aimed at the general reader who may not be an expert in the chosen topic. Proposals for a review should be discussed first with the review editors.
MANUSCRIPTS should be submitted in English (British) in electronic format in 10-point Times New Roman font and double spaced. Electronic versions of text and tables should be compatible with WORD, with figures as pdf or jpg files, and sent as email attachments or CDroms. All manuscripts will be refereed.
THE TITLE should reflect the content of the paper and be in BOLD CAPITALS (11-point) and centrally aligned. Generic and specific names should be in italics and any title containing a generic or specific name should be followed by the family name in brackets e.g.

***TRICHOMANES SPECIOSUM* (HYMENOPHYLLACEAE) IN SOUTHERN SPAIN**

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MORTON, C.V. 1947. The American species of *Hymenophyllum*, section *Sphaeroconium*. Contr. U.S. Natl. Herb. 29(3): 139-201.
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DISTRIBUTION PATTERNS AND PRIORITIES FOR CONSERVATION OF IRANIAN PTERIDOPHYTES

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ABSTRACT

Iran is the most diverse region of Southwestern Asia and is the main zone of the Iranian plateau, located at the intersection of the Irano-Turanian and Sudano-Zambezian floristic regions. The pteridophyte flora of Iran is mainly a Mediterranean, European type flora, but with a few African elements in the southwest and a small ancient Asiatic component related to Sino-Himalayan species in the north. The northern slopes of the Alborz mountain system are significantly affected by the humidity of the Caspian Sea, which has created the conditions for the survival of a temperate zone and the concentration of many moisture-loving species (e.g. ferns, horsetails etc.). However, there are also a few species of ferns in the arid zones of the country. In order to analyze the species richness mapping, 0.25° × 0.25° universal transverse Mercator grid cells (25 km^2 with the exception of boundary areas) were used as units of study. The conservation status of taxa was evaluated by GeoCAT, Kew. According to the present study, the Iranian pteridophyte flora includes 62 taxa of 27 genera belonging to 16 botanical families. Dryopteridaceae include the greatest numbers of threatened species (CR, EN, and VU) of Iranian pteridophytes. Some Iranian pteridophyes show a significant decline in populations resulting from vulnerability of their habitat. Unfortunately, illegal over-harvesting of different ferns for ornamental purposes in flower shops has caused a population threat to many species. The present study determines the complete overall distribution pattern for occurrence of any Iranian Pteridophyte in Iran species and describes species-based and ecosystem-based conservation priorities for habitat protection inside and outside the habitat.

INTRODUCTION

Pteridophytes (e.g. Equisetales, Marattiales, Ophioglossales, Psilotales, and Polypodiales) (Simpson, 2006; PPG-I 2016) including about 11000 (Pryer et al., 2004) to 13000 (Smith et al., 2006) taxa. In addition, they are considered as the second biggest plant Division (Prance, 2001). They are extensively distributed in diverse biomes (Moran, 2008). Distribution patterns of pteridophytes are strongly related to climatic as well as substrate factors (Given, 1993) and to phytogeographical zones and migration. Some of the families (e.g. Osmundaceae and Schizaeaceae) have an ancient origin (150-300

million years old), but others (e.g. modern fern families) are as old as flowering plants (50-100 mya) (Schneider et al., 2004). Moreover, their presence reflects ecological characteristics of habitats (e.g. soil features, climate, as well as light intensity (Patil et al., 2016; Della & Falkenberg, 2019). Additionally, pteridophytes are prominent bio-indicators (e.g. soil nutrient, habitat fragmentation, climate change, fire and etc.) and can be used for the evaluation of the effectiveness of protected areas based on diversity (Zuquim et al., 2014; Gutiérrez-Lozano et al., 2017). For example, *Pteridium aquilinum* is mainly established in damaged secondary habitats (roadsides, scattered forest, farmland and other anthropogenic habitats) in the Hyracanian forest region (Akhani et al., 2010). Some pteridophytes including *Asplenium* spp., *Blechnum* spp., *Adiantum* spp., *Polypodium* spp., *Pteris* spp., *Equisetum* spp., and *Thelypteris* spp. have been reported as indicators of soil and habitat features (Della & Falkenberg, 2019). Additionally, some species of pteridophytes have medicinal or ornamental usages (Lira & Riba, 1993; Pérez-García et al., 1995). However, pteridophytes are not classified as a group of plants with high economic value though some of them are cultivated or gathered for food or for ornamental uses. In addition, a few ferns play an important role in phytoremediation of contaminated soils (Xie et al., 2009) as well as removing some chemical pollutants from the air (Kim et al., 2010). These special characteristics make this group a suitable case for geo-botanical studies (Kessler, 1999). Although global diversity patterns of ferns show several similarities with that of flowering plants (Barthlott et al., 2007), there are prominent differences (Kramer, 1993). The richness of fern species increases from the poles toward the equator more sharply than in seed plants. Furthermore, their altitudinal patterns vary in different biomes (Mehltreter et al., 2010).

Despite the importance of this group in the world, a few geographical and ecological studies were conducted in Iran. Iran as the most diverse region of Southwestern Asia and the main zone of the Iranian plateau is located at the intersection of Irano-Turanian and Sudano-Zambezian floristic regions (Takhtajan, 1986). Furthermore, its complex tectonic history and diverse climates with high speciation potential has led to shaping a centre of diversity and endemism of vascular plant taxa in the region (Zohary, 1973; Mehrabian et al., 2020). The northern slopes of the Alborz mountain system, which are significantly affected by the humidity of the Caspian Sea created the conditions for the establishment of a temperate zone and the concentration of many moisture-loving species (e.g. ferns, horsetails etc.). However, there are a few species of pteridophytes in the arid zones of the country. Basic studies on pteridophytes date back to Wendelbo (1976) that have been published as an annotated checklist of the ferns of Iran. Afterwards, Khoshravesh et al. (2009) released the ferns and ferns allies in Iran that mainly focused on floristic aspects. Fraser-Jenkins (2014) published a scientific reference titled "Ferns and allies of the far-west Indo-Himalaya (Afghanistan, Pakistan and Kashmir) and Iran - revised checklists, classification and phytogeography". In this revised checklist, 61 taxa of pteridophytes have been reported for Iran, 85% of which are European elements (Fraser-Jenkins, 2014). Besides, Azadi (2017) provided a taxonomic reference on Iranian Cryptogams in the frame of the Flora of Iran. Insufficient attention has been paid to distribution patterns, diversity centres, conservation status as well as priority zones for the conservation of pteridophytes on a national scale in Iran. Additionally, the Hyrcanian (Caspian) forests of northern Iran and southern Azerbaijan as the main centre of diversity of pteridophytes in the Region (deciduous broad-leaved forest) are classified as a Global 200 eco-region by the World Wide Fund for Nature (WWF). Because of the lack of institutes studying diversity despite the importance of ecological data analysis, a geo-botanic analysis seems

to be necessary. This study aims to identify distribution patterns, conservation status and priority zones for conservation management of Iranian pteridophytes.

MATERIAL AND METHODS

Study Area

This assessment covered the geographical boundaries of Iran thus including a total surface area of 1.6 million km^2 at 25°-40° N longitude and 44°-64° E latitude. Most of the study area was concentrated on the northern slopes of the Alborz in accordance with the Hyrcanian Province that stretches from Astara (North West) to the area near Gorgan (Northeast of Iran). The Alborz Mountains system has created a natural barrier intercepting humidity from the Caspian Sea to central Iran. The Alborz Mountains are known for their multifaceted geological history from the middle to late Triassic Eo-Cimmerian orogeny resulting from Arabia-Eurasia continental collision (Stöcklin, 1974; Ballato et al., 2013). The deciduous broadleaf Hyrcanian forests have continued from Caspian lowlands to an altitude of 2500 meters (in some regions to more than 2800 meters) (Sabeti, 1994) Hyrcanian Forests are classified as in the Northern geomorphologic of Iran (Alaie Taleghani, 2002). The area is composed of quaternary deposits in the eastern zones and sedimentary, igneous, and volcanic-sedimentary rocks in the central and western zones (Geological department of IRAN 2001). Soils of the area are mainly composed of fine-textured alluvial, brown forest soils (including gray-brown podzolic soils), and lithossols-brown forest soils and rendzinas soils (Dewan & Famouri, 1964). These areas are affected by the Mediterranean pluviseasonal-oceanic effect (Mpo) (Djamali et al., 2011) revealing a short period of dry summer as well as scattered precipitation especially in upland areas. The rainfall decreases from Western (c. 1430mm) to Eastern Parts (280mm) of the region (Gholizadeh et al., 2020).

METHODS

Species occurrence data set

The Iranian pteridophyte data set was formed using the distributional data available in the CRFJ's Iranian collections of ferns (1968-1977), Iran-revised checklist of ferns and allies (Fraser-Jenkins, 2014), Flora of Iran (Kolbadi, 2009; Azadi, 2017), and the recent monograph of ferns and fern allies of Iran (Khoshravesh et al., 2009) as well several scientific excursions in different zone of Iran by authors. For some new species, the spatial information given in some recent literature has been adopted (Gholipour & Greuter, 2010). Additional distribution data were also obtained from the herbarium of the Shahid Beheshti University as well as the virtual herbaria such as W, LD, MW, NMNH, E, NHN, and KTU. Herbarium acronyms follow Thiers (2019). The Iran-revised checklist of ferns and allies (Fraser-Jenkins, 2014) is the main scientific base used for the nomenclature of the species. The final database used in this study comprised 2582 geo-referenced entries.

Species richness

Species richness (number of species per site) is one of the most important criteria used in conservation biology and it was estimated simply as the total count of species within each grid-cell (Linder, 2001). In order to analyze the species richness mapping, 0.25° × 0.25° universal transverse Mercator grid cells (25 km^2 with the exception of boundary areas) were used as units of study. In addition, a species richness map was drawn using the circular neighborhood point-to-grid richness analysis tool based on 10×10 km grid

cells with a radius of 25 km. ArcView version 10.3 (ESRI 2000) and DIVA-GIS 7.3 were used to make these analyses.

Conservation status and Rarity

The conservation status of taxa was evaluated by GeoCAT, Kew (http://geocat.kew.org/; Buchman et al., 2011). GeoCAT (Geospatial Conservation Assessment Tool) is an open-source, browser-based tool that produces fast geospatial analysis for the Regional Red List Assessments. Extent of occurrence (EOO) and area of occupancy (AOO) were applied to classify the threat status of species. The index of species rarity in the study area (RI) was conducted based on Williams et al. (1996). The RI was calculated as the inverse of the number of cells with documented species throughout the board area as follows RI=1/Ci, where Ci is the number of grid cells and 1 is the number of existing taxa. The scoring showed a range from zero (0) to one (1) for this index.

Principal component analysis (PCA)

In order to investigate the relationships between species distribution and environmental variables, 12 variables were subjected to a principal component analysis (PCA) using the past software version 3. Five edaphic parameters (PH, organic carbon, percentage of clay and sand, CEC and depth of soil), three topographic variables (aspect, slope, and altitude), two climatic variables (annual precipitation and annual temperature), and solar radiation were used for principal component analysis (PCA).

RESULTS

Pteridophyte diversity of Iran

Our studied taxa including six phylogenetic clades following Osmundales, Salviniales, Equisetales, Polypodiales, Ophioglossales and Psilotales (PPG-I 2016). According to the present study, the Iranian pteridophyte flora includes 62 taxa of 27 genera belonging to 16 botanical families. Dryopteridaceae with 16 taxa is the largest family in Iran, followed by and Pteridaceae and Aspleniaceae with 11 taxa (Figure 1). The rest of the families have less than 5 species. In addition, Pteridaceae (7), and Dryopteridaceae (4) have the highest number of genera in Iran. Moreover, *Asplenium* (11) and *Dryopteris* (8) have the largest number of taxa in studied taxa in Iran. However, *Blechnum*, *Pteridium*, *Marsilea*, *Onoclea*, *Botrychium*, *Osmunda*, *Psilotum*, *Adiantum*, *Anogramma*, *Onychium*, *Paragymnopteris* L, *Azolla*, *Salvinia, Thelypteris* and *Woodsia* have only one species in Iran (Table. 1). The pteridophytes were distributed in elevations ranging between -31 m a.s.l (*Dryopteris pallida* (Bory) C. Chr. ex Maire & Petitm. subsp. *raddeana* (Fomin) Nardi) to 4350 m a.s.l. (*Cystopteris fragilis* (L.) Bernh. subsp. *fragilis* in Iran (Table 2). Figure 2 illustrates some Iranian pteridophyte species.

Species richness

The grid-based map of pteridophytes richness reveals that one grid cell in Gilan province has the highest number of species (35 species) (Figure 3A, B). We categorized the species richness map cells into five groups of 1 to 35 species. Five grid cells in parts of the Gilan and Mazandaran provinces have 22 to 28 species. Besides, 14 grid cells have 15-21 species, often concentrated in Golestan, Mazandaran, Gilan and East Azarbaijan provinces. Although the greatest species richness occurs in northern Iran, there are more than 145 grid cells in other parts of Iran, including the northeast, northwest, east, west, southeast, southwest, south, and central Iran, which have between 1-7 species of

pteridophytes. The point-to-grid statistical analysis was used to identify the main hotspots (Fig.3B). Based on the richness map, the west parts of Mazandaran, Gilan, southern zones of Ardebil, Northern parts of Zanjan, Ghazvin, Alborz, and Tehran provinces are the main hotspots of pteridophyte richness in Iran.

Rare taxa and Conservation status (IUCN Red List Category)

Dryopteridaceae includes the greatest numbers of threatened species (CR and VU) of Iranian pteridophytes (Figure 4 & Table 1) followed by Aspleniaceae. Figure 4B demonstrates the IUCN categories for the taxa studied and about 20 % of these species are at high risk of extinction. Fortunately, many species or subspecies, such as *Asplenium adiantum-nigrum* L. subsp. *adiantum-nigrum*, *Asplenium ceterach* L. subsp. *ceterach*, *Equisetum arvense* L., *Polypodium vulgare* L. and *Adiantum capillus- veneris* L. are at low risk of extinction due to their widespread distribution in Iran (Table. 2).

According to Table 2, 16/4% (10 species) of the taxa such as *Asplenium trichomanes* L. subsp. *pachyrachis* (Christ) Lovis & Reichst., *Cyrtomium fortunei* J. Sm., *Polystichum lonchitis* (L.) Roth, *Ophioglossum polyphyllum* A. Braun, *Osmunda regalis* L., *Oeosporangium coriaceum* (Decne.) Fraser-Jenk. & Pariyar, *Paragymnopteris marantae* (L.) K.H. Shing, *Woodsia alpina* (Bolton) S.F. Gray, *Cystopteris fragilis* (L.) Bernh. subsp. *diaphana* (Bory) Litard. and *Polypodium cambricum* L. are very rare in the flora of Iran. *Asplenium viride* Huds., *Blechnum spicant* (L.) Roth, *Dryopteris dilatata* (Hoffm.) A. Gray, *Equisetum palustre* L., *Marsilea quadrifolia* L., *Ophioglossum lusitanicum* L., *Thelypteris limbosperma* (All.) H.P. Fuchs. *Equisetum arvense* L., *Onoclea struthiopteris* (L.) Roth, *Polystichum woronowii* Fomin, *Polypodium vulgare* L., *Asplenium trichomanes* L. subsp. *trichomanes* with occurrence in more than seven cells, have the widest range of distribution among pteridophytes.

Principal component analysis (PCA)

In order to determine the most important variables affecting the distribution and diversity of pteridophyte species in the main hotspots of species richness (Mazandaran and Gilan provinces), PCA analysis was used. For this purpose, PC 1=3.69923 axis due to having a larger contribution of the Eigen value were examined (Table 3). The results of this analysis show that the percentage of sand, organic carbon, aspect, slope, CEC, insolation, annual precipitation and altitude are positively correlated with the first axis and percentage of clay, silt, soil pH, annual temperature and depth of soil are negatively correlated with the first axis (Figure 5).

DISCUSSION

The results of the present study show that high species richness occurs in the Gilan and Mazandaran provinces. The ecological heterogeneity resulting from diverse rates of precipitation (from 530 mm in the east to 1350 mm in the west), different ranges of temperature (20°-30° C) (Sagheb-Talebi et al., 2014), six types of soils (Dewan & Famouri, 1964) as well as an altitudinal gradient (-27 m a. s.l. to 2500m a.s.l), forms a variety of habitats and plant communities in the Hyrcanian forests and each of them has created ecological zones for various species of pteridophytes. Because of their great dispersal abilities, pteridophytes have mainly been considered as representing low values of beta diversity (Qian, 2009). However, our results show high beta diversity resulting from ecological heterogeneity of pteridophyte habitats in Iran. A similar pattern of diversity has been found in Mexican mountain habitats (Halffter et al., 2005), Neotropical

Table 1. Elevation patterns of Iranian pteridophytes

Family	Scientific name	Elevation range (species)m	Elevation range (Genus) m	Elevation range (Family) m
Aspleniaceae	*Asplenium septentrionale* (L.) Hoffm. subsp. *septentrionale*	900- 2700	-20-3700	-20-3700
	Asplenium adiantum-nigrum L. subsp. *adiantum-nigrum*	10 -2850		
	Asplenium ceterach L. subsp. *ceterach*	20-2500		
	Asplenium ruta-muraria L. subsp. *dolomiticum* Lovis & Reichst.	500-3400		
	Asplenium ruta-muraria L. subsp. *ruta-muraria*	500-3400		
	Asplenium scolopendrium L.	-20 – 2100		
	Asplenium trichomanes L. subsp. *pachyrachis* (Christ) Lovis & Reichst.	1000		
	Asplenium trichomanes L. subsp. *quadrivalens* D.E.Mey.	50-1900		
	Asplenium trichomanes L. subsp. *trichomanes*	100-2700		
	Asplenium viride Huds.	1500 – 3700		
	Asplenium lepidum C.Presl subsp. *haussknechtii* (Godet & Reut. *ex* Milde) Brownsey	230 – 3330		
Blechnaceae	*Blechnum spicant* (L.) Roth	500 - 1700	500 - 1700	500 – 1700
Dennstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn.	0 - 2047	0 - 2047	0 – 2047
Dryopteridaceae	*Cyrtomium fortunei* J. Sm.	520	520	-31 – 3000
	Dryopteris affinis (R. Lowe) Fraser-Jenk. subsp. *borreri* (Newm.) Fraser-Jenk.	500	-31 - 3000	
	Dryopteris affinis (R. Lowe) Fraser-Jenk. subsp. *persica* Fraser-Jenk.	100-1750		
	Dryopteris affinis (R. Lowe) Fraser-Jenk. subsp. *pontica* Fraser-Jenk.	400		

Table 1. continued

Family	Scientific name	Elevation range (species)m	Elevation range (Genus) m	Elevation range (Family) m
Dryopteridaceae	*Dryopteris wallichiana* (Spreng.) Hyl. subsp. *coriacea* (Fraser-Jenk.) Fraser-Jenk.	200-210		
	Dryopteris caucasica (A.Braun) Fraser-Jenk.	20 - 2750		
	Dryopteris dilatata (Hoffm.) A.Gray	120 - 1200		
	Dryopteris filix-mas (L.) Schott subsp. *filix-mas*	20 - 3000		
	Dryopteris pallida (Bory) C.Chr. *ex* Maire & Petitm. subsp. *raddeana* (Fomin) Nardi	-31 - 1770		
	Cystopteris fragilis (L.) Bernh. subsp. *diaphana* (Bory) Litard.	1200-2760	180 - 8800	
	Cystopteris fragilis (L.) Bernh. subsp.*fragilis*	180-4350	180 - 8800	
	Cystopteris fragilis (L.) Bernh. subsp. *dickieana* (R.Sim) Hyl.	800-3800	180 – 8800	
	Polystichum aculeatum (L.) Roth	-20 - 3000	-20 – 3000	
	Polystichum braunii (Spenn.) Fée	150 - 2600		
	Polystichum lonchitis (L.) Roth	2500		
	Polystichum woronowii Christ	-13 - 1525		
Equisetaceae	*Equisetum arvense* L.	130 - 3000	-25 - 2750	-25 – 3000
	Equisetum palustre L.	500 - 1720		
	Equisetum ramosissimum Desf.	600 - 2750		
	Equisetum telmateia Ehrh.	-25 - 2350		
Marsileaceae	*Marsilea quadrifolia* L.	-30 to 140	-30 - 140	-30 – 140
Onocleaceae	*Onoclea struthiopteris* L.	10 - 2050	10 - 2050	10 – 2050
Ophioglossaceae	*Botrychium lunaria* (L.) Sw.	50 - 3200	50 - 3200	0 – 3200
	Ophioglossum lusitanicum L.	140 - 300	0 - 2500	

Table 1. continued

Family	Scientific name	Elevation range (species)m	Elevation range (Genus) m	Elevation range (Family) m
Ophioglossaceae	*Ophioglossum polyphyllum* A. Braun	40		
	Ophioglossum vulgatum L.	0 - 2500		
Osmundaceae	*Osmunda regalis* L.	1000 - 1500	1000 - 1500	1000 – 1500
Polypodiaceae	*Polypodium interjectum* Shivas	-21 - 1700	-21 - 2750	-21 – 2750
	Polypodium vulgare L.	10 - 2750		
	Polypodium cambricum L.			
Psilotaceae	*Psilotum nudum* (L.) P.Beauv.	60 - 81	60 - 81	60 – 81
Pteridaceae	*Adiantum capillus-veneris* L.	20 - 3500	20 - 3500	20 – 3500
	Anogramma leptophylla (L.) Link	150 - 1900	150 - 1900	
	Oeosporangium persicum (Bory) Fraser-Jenk. & Pariyar	450 - 2250	0 - 3000	
	Oeosporangium pteridioides (Reichard) Fraser-Jenk. & Pariyar subsp. *acrosticum* (Balbis) Fraser-Jenk. & Pariyar	0 - 3000		
	Oeosporangium coricaeum (Decne.) Fraser-Jenk. & Pariyar	810 to 1500		
	Cosentinia vellea (Aiton) Tod. subsp. *vellea*	60 - 2000	60 -2000	
	Onychium divaricatum (Poir.) Alston	10 - 3300	10 - 3300	
	Paragymnopteris marantae (L.) K.H.Shing	650 - 1700	650 - 1700	
	Pteris cretica L. subsp. *laeta* (Wall. *ex*Ettingsh.) Fraser-Jenk.	5 - 1750	5 - 1750	
	Pteris dentata Forssk. subsp. *flabellata* (Thunb.) Runem.	20 - 1700		
	Pteris vittata L. subsp. *vittata*	550 – 1400		
Salviniaceae	*Azolla filiculoides* Lam.	-20 - 1350	-20 - 1350	-30 – 1350
	Salvinia natans (L.) All.	-30 - 50	-30 - 50	

Table 1. continued

Family	Scientific name	Elevation range (species)m	Elevation range (Genus) m	Elevation range (Family) m
Thelypteridaceae	*Thelypteris limbosperma* (All.) H.P.Fuchs	100 - 1600	10 - 1500	
	Thelypteris palustris Schott. subsp. *palustris*	10 - 1500		
Woodsiaceae	*Woodsia alpina* (Bolton) S.F.Gray	650 - 2400	650 - 2400	20 – 8800
Athyriaceae	*Athyrium filix-femina* (L.) Roth	20 - 2600	20 - 2600	20-3000

Forests (Tuomisto & Poulsen, 1996) and Rain Forest ferns (Jones et al., 2006). Besides, a strongly positive correlation has been reported between richness of angiosperms and pteridophytes (Kreft et al., 2010). Our results showing the high diversity centres of Iranian pteridophytes is in accordance with centres of diversity of Iranian macrophytes (Mehrabian et al., 2020). Ferns and their relatives play important roles in function as well ecosystem structure, in tropical rainforest as well as temperate regions (Kessler, 2010).

According to the results of PCA analysis, different populations of pteridophyte species have high diversity in terms of ecological conditions, among which annual rainfall, soil organic carbon content and altitude have a positive correlation with the diversity of pteridophytes. Climate is also one of the most important factors affecting the characteristics of soil types, including soil organic carbon, which increases with decreasing temperature and increasing rainfall (Singh et al. 2017). Therefore, climate change and increasing temperature will reduce soil organic carbon and consequently will reduce the diversity and tend towards the extinction of populations of Iranian pteridophyte species.

Priorities and Conservation management

The coastal zone of the Caspian Sea (Hyrcanian province) as well as the mountainous to subalpine meadows of Northern slopes of the Alborz range, together with the Euxinean Province including relict elements of Tertiary flora are the main diversity centres of Iranian pteridophytes (Browicz, 1989). Paleo-botanical studies in this area have identified some fossils belonging to deciduous plant taxa that date back to 82,000 ± 8,800 BP (Montazeri et al., 2011), which emphasizes the antiquity of these Tertiary Era relict Hyrcanian forests (Sagheb-Talebi et al., 2014) as a natural heritage requiring conservation management. Some Iranian pteridophytes show a significant decline in populations resulting from vulnerability of their habitat. Unfortunately, the illegal over-harvesting of different pteridophytes (e.g *Pteris* spp. *Athyrium* spp. *Asplenium* spp., etc. for ornamental purposes in flower shops has caused a population threat to many species (unpublished personal data of authors).

Endangered pteridophytes in Iran clarified from our study are *Polystichum lonchitis, Ophioglossum polyphyllum, Osmunda regalis, Polypodium cambricum, Asplenium trichomanes* L. subsp. *pachyrachis* and *Paragymnopteris marantae*, which we confirm

Table 2. Conservation status and rarity index of pteridophytes of Iran.

Family	Scientific name	Conservation Status	RI	Threatened factors
Aspleniaceae	*Asplenium septentrionale* (L.) Hoffm. subsp. *septentrionale*	LC	0.14	OH, LUC
	Asplenium adiantum-nigrum L. subsp. *adiantum-nigrum*	LC	0.06	OH
	Asplenium ceterach L. subsp. *ceterach*	LC	0.03	OH, LUC
	Asplenium lepidum C.Presl subsp. *haussknechtii* (Godet & Reut. *ex* Milde) Brownsey	LC	0.16	OH, LUC
	Asplenium ruta-muraria L. subsp. *ruta-muraria*	LC	0.07	OH, LUC
	Asplenium ruta-muraria L. subsp. *dolomiticum* Lovis & Reichst.	LC	0.05	OH, LUC
	Asplenium scolopendrium L.	LC	0.06	OH, LUC
	Asplenium trichomanes L. subsp.*pachyrachis* (Christ) Lovis & Reichst.	CR	1	OH, LUC
	Asplenium trichomanes L. subsp. *quadrivalens* D.E.Mey.	LC	0.08	OH, LUC
	Asplenium trichomanes L. subsp. *trichomanes*	LC	0.05	OH, LUC
	Asplenium viride Huds.	LC	0.25	OH, LUC
Blechnaceae	*Blechnum spicant* (L.) Roth	VU	0.33	OH, LUC
Dennstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn.	LC	0.06	OH, LUC
Dryopteridaceae	*Cyrtomium fortunei* J. Sm.	CR	1	OH, LUC, RH
	Dryopteris affinis (R.Lowe) Fraser-Jenk. subsp. *borreri* (Newm.) Fraser-Jenk	VU	0.33	OH, LUC
	Dryopteris affinis (R.Lowe) Fraser-Jenk. subsp. *persica* Fraser-Jenk.	NT	0.2	OH, LUC
	Dryopteris affinis (R.Lowe) Fraser-Jenk. subsp. *pontica* Fraser-Jenk.	VU	0.5	OH, LUC
	Dryopteris wallichiana (Spreng.) Hyl. subsp. *coriacea* (Fraser-Jenk.) Fraser-Jenk.	NT	0.2	OH, LUC

Table 2. Continued

Family	Scientific name	Conservation Status	RI	Threatened factors
Dryopteridaceae	*Dryopteris caucasica* (A.Braun) Fraser-Jenk.	LC	0.08	OH, LUC
	Dryopteris dilatata (Hoffm.) A. Gray	LC	0.25	OH, LUC
	Dryopteris filix-mas (L.) Schott subsp. *filix-mas*	LC	0.08	OH, LUC
	Dryopteris pallida (Bory) C.Chr. *ex* Maire & Petitm. subsp. *raddeana* (Fomin) Nardi	LC	0.07	OH, LUC
	Cystopteris fragilis (L.) Bernh. subsp. *diaphana* (Bory) Litard.	CR	1	OH, LUC
	Cystopteris fragilis (L.) Bernh. subsp. *fragilis*	LC	0.02	OH, LUC
	Cystopteris fragilis (L.) Bernh. subsp. *dickieana* (R.Sim) Hyl.	LC	0.1	OH, LUC
	Polystichum aculeatum (L.) Roth	LC	0.06	OH, LUC
	Polystichum braunii (Spenn.) Fée	LC	0.09	OH, LUC
	Polystichum lonchitis (L.) Roth	CR	1	OH, LUC, RH
	Polystichum woronowii Christ	LC	0.09	OH, LUC
Equisetaceae	*Equisetum arvense* L.	LC	0.06	OH, LUC
	Equisetum palustre L.	NT	0.25	OH, LUC
	Equisetum ramosissimum Desf.	LC	0.03	OH, LUC
	Equisetum telmateia Ehrh.	LC	0.05	OH, LUC
Marsileaceae	*Marsilea quadrifolia* L.	VU	0.25	OH, LUC
Onocleaceae	*Onoclea struthiopteris* L.	LC	0.11	OH, LUC
Ophioglossaceae	*Botrychium lunaria* (L.) Sw.	LC	0.1	OH, LUC
	Ophioglossum lusitanicum L.	EN	0.5	OH, LUC, RH
	Ophioglossum polyphyllum A.Braun	CR	1	OH, LUC, RH
	Ophioglossum vulgatum L.	LC	0.09	OH, LUC
Osmundaceae	*Osmunda regalis* L.	CR	1	OH, LUC, RH
Polypodiaceae	*Polypodium interjectum* Shivas	LC	0.07	OH, LUC

Table 2. Continued

Family	Scientific name	Conservation Status	RI	Threatened factors
Polypodiaceae	*Polypodium vulgare* L.	LC	0.07	OH, LUC
	Polypodium cambricum L.	CR	1	OH, LUC
Psilotaceae	*Psilotum nudum* (L.) P.Beauv.	EN	0.5	OH, LUC, RH
Pteridaceae	*Adiantum capillus- veneris* L.	LC	0.014	OH, LUC
	Anogramma leptophylla (L.) Link	LC	0.08	OH, LUC
	Oeosporangium persicum (Bory) Fraser-Jenk. & Pariyar	LC	0.04	OH, LUC
	Oeosporangium pteridioides (Reichard) Fraser-Jenk. & Pariyar subsp. *acrosticum* (Balbis) Fraser-Jenk. & Pariyar	LC	0.02	OH, LUC
	Oeosporangium coriaceum (Decne.) Fraser-Jenk. & Pariyar	CR	1	OH, LUC, RH
	Cosentinia vellea (Aiton) Tod. subsp. *vellea*	LC	0.05	OH, LUC
	Onychium divaricatum (Poir.) Alston	LC	0.05	OH, LUC
	Paragymnopteris marantae (L.) K.H. Shing	CR	1	OH, LUC, RH
	Pteris cretica L. subsp. *laeta* (Wall. *ex* Ettingsh.) Fraser-Jenk.	LC	0.09	OH, LUC
	Pteris dentata Forssk. subsp. *flabellata* (Thunb.) Runem.	LC	0.16	OH, LUC
	Pteris vittata L. subsp. *vittata*	LC	0.14	OH, LUC
Salviniaceae	*Azolla filiculoides* Lam.	LC	0.14	OH, LUC
	Salvinia natans (L.) All.	LC	0.16	OH, LUC
Thelypteridaceae	*Thelypteris limbosperma* (All.) H.P.Fuchs	NT	0.2	OH, LUC
	Thelypteris palustris Schott. subsp. *palustris*	LC	0.16	OH, LUC
Woodsiaceae	*Woodsia alpina* (Bolton) S.F.Gray	EN	1	OH, LUC, RH
Athyriaceae	*Athyrium filix-femina* (L.) Roth	LC	0.07	OH, LUC

OV: Overharvest, LUC: Land Use Change, RH: Restricted Habitats, RI: Rarity Index, CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near Threatened

Table 3. The Eigen value and percentage of variance for all environmental variables across the PCA analysis

PC	Eigenvalue	% variance
1	3.6992300	30.82700
2	2.1645700	18.03800
3	1.9094000	15.91200
4	1.2677700	10.56500
5	0.9194240	7.66190
6	0.7588710	6.32390
7	0.4377380	3.64780
8	0.2847040	2.37250
9	0.2545270	2.12110
10	0.1523460	1.26950
II	0.0974 129	0.81177
12	0.0540075	0.45006

as Critically Endangered [CR]. In addition, *Woodsia alpina*, *Psilotum nudum,* and *Ophioglossum lusitanicum* are endangered pteridophytes classified as the priority taxa for conservation. *Psilotum nudum* was reported in 2003 by Rezaei & Khangholi in restricted zones in Hyrcanian Forest in Western Mazandaran. Due to its charismatic features and unusual morphological structure, it attracted too much attention and even many botanists have collected this limited species which has led to a severe decline in its population; it has now become a highly endangered species. *Ophioglossum lusitanicum* is a cosmopolitan species, widely distributed in the Mediterranean, Western

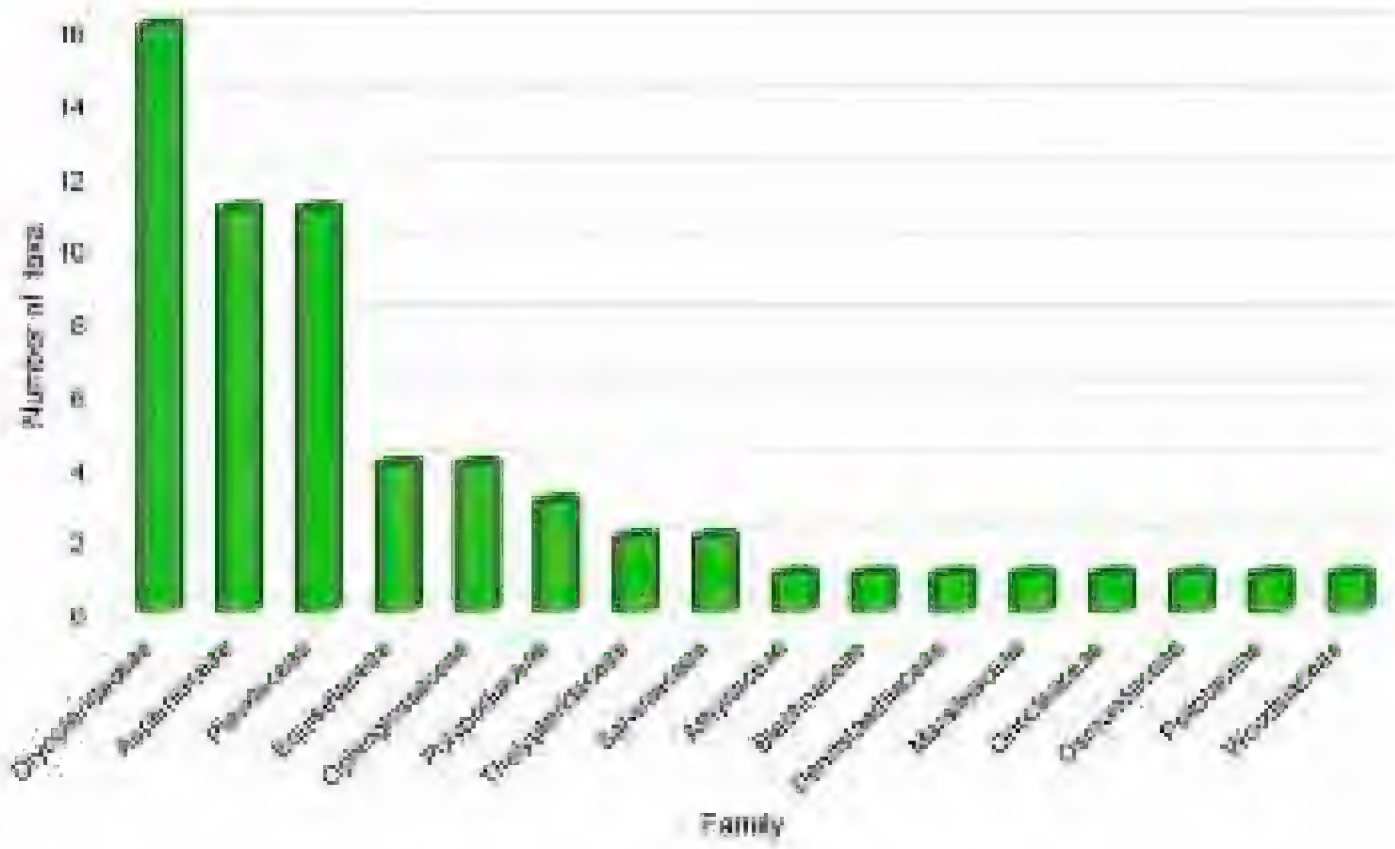

Figure 1. Family diversity of Iranian pteridophytes.

Figure 2. Some Iranian pteridophyte taxa: a) *Asplenium ceterach* subsp. *ceterach* b) *Asplenium trichomanes* subsp. *quadrivalens* c, d) *Polystichum aculeatum* e) *Oeosporangium pteridioides* subsp. *acrosticum* f) *Asplenium scolependrium* g, h) *Equisetum telmateia* i) *Pteridium aqulinum* j) *Azolla filiculoides.*

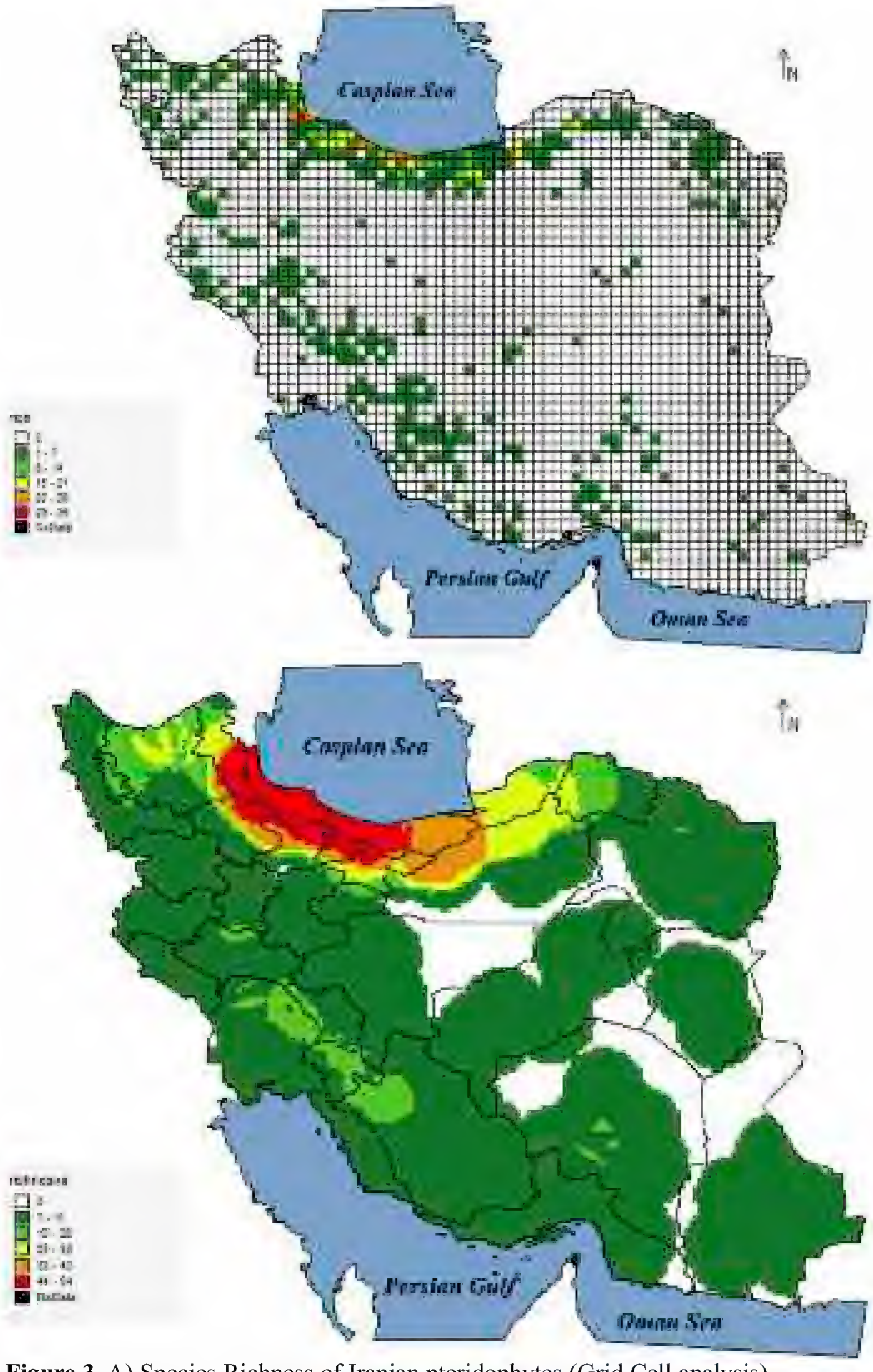

Figure 3. A) Species Richness of Iranian pteridophytes (Grid Cell analysis)
B) Species Richness of Iranian pteridophytes (Circular neighbourhood point-to-grid analysis)

European and in subtropical areas (Akeroyd, 1993; Peruzzi et al., 2003), but usually very rare within each country. It occurs in a very restricted zone in Northern Iran, where it prefers primary stages of succession and disturbed ecosystems. Because it also has a strong dependency on mycorrhizal fungi (Merckx, 2013), and requires a specific habitat, it is very vulnerable to ecological fluctuations and requires conservation by preserving the habitat undisturbed. *Ophioglossum polyphyllum* is distributed from tropical and southern Africa to Iran, Afghanistan, and Northern India (Miller, 1996). This is another species that is very restricted and rare and is highly endangered (CR), having been reported only from a restricted area in Hormozgan province (Miller, 1996; Eskandari & Shirzadian, 2007). Because it is habitat-specific, the locality requires to be preserved intact. *Osmunda regalis* is considered as critically endangered in Iran (and also in Switzerland, Croatia and Hungary) or as a vulnerable species in Poland (Zarzycki & Szelag, 2006). It requires a particular type of marsh habitat, which therefore requires protection to enable it to survive. As the spores of this species are chlorophyllous they cannot survive dessication and it can only reproduce locally as long as the habitat remains undisturbed and undrained. But it has been found that storing its spores in freezing conditions increases their longevity and it can be used as an *ex-situ* conservation

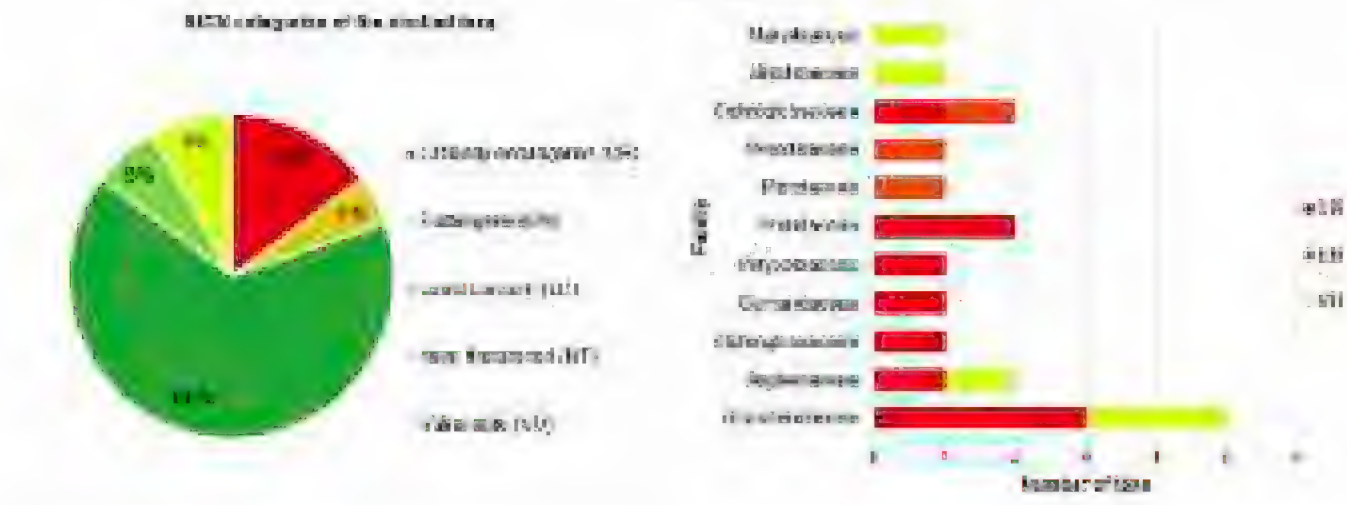

Figure 4. IUCN categories of the studied taxa.

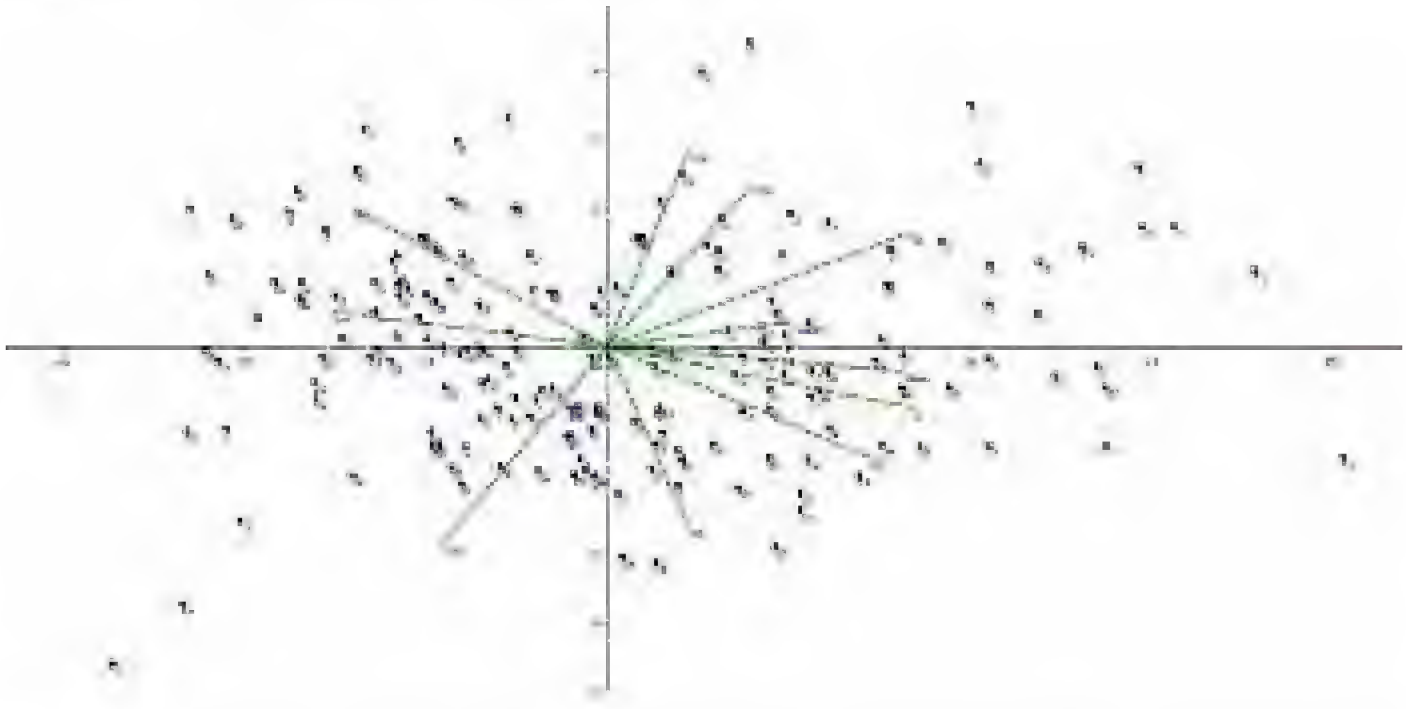

Figure 5. Principal component analysis (PCA) plot of environmental variables in the study area.

methodology to help in the transferral of the species from particular threatened locations (Mikuła et al., 2015). *Polystichum lonchitis* occurs in higher-altitude rocky, mountain-zones of Asia, Northwestern Africa, Europe, and North America. This species grows in very limited areas in Gilan and Mazandaran provinces and is extremely endangered due to overgrazing and its small distributional area. It can be cultivated from spores but would not survive at lower altitudes and it is therefore important to restrict some areas from grazing which leads to its destruction.

Because of the specific need for water to allow their sexual reproductive system to function as well as high dependency on habitat humidity, ferns are extremely sensitive to local climate changes (Ibars & Estrelles, 2012). Local or regional climate change, especially in temperate forests such as the Hyrcanian forests in Iran (Shooshtari et al., 2018), threaten the survival of many species of ferns. In addition, high negative pressure on their habitat (e.g. overgrazing, land use change, fire etc.) (Akhani et al., 2010; Shooshtari et al., 2018) emphasize the need to implement rapid *in-situ* and *ex-situ* conservation plans nationally. Targeted cultivation followed by reintroduction into wild populations, combined with encouraging appreciation of their economic value for local communities, will help protect these species. *In-situ* conservation will be most effective when species are located in protected centres of diversity or hot spots, otherwise it will cost significant time and funds (Chan, 2002). *Ex-situ* conservation (e.g. cultivation from spores, or sometimes *in-vitro* methods, living gene-banks etc.) as a supportive method to *in-situ* conservation, improves the result of conservation actions on pteridophytes. But because reintroduction plans can be expensive and do not always result in successful establishment of the individual plants, the first step of conservation is to avoid population extinction in natural habitats (Rae, 1999). Although some of the diversity centres of these species are located within protected areas, ferns are unfortunately neglected as being of little priority in conservation perspectives and the destruction of these species has received less attention. Targeted training and informing environmental guardians as well as local people must therefore play an important rôle in their conservation. In addition, based on economical valuation as well as assessment of ecosystem services, the important functions of these species should be explained to people and policy makers for efficient conservation (Nunes & van den Bergh, 2001).

CONCLUSION

According to the findings of this research, we suggest that all the areas with high species richness be protected. Also, given that 20% and 16.4% of all species are highly endangered or very rare, respectively, planning to protect them is essential. The success of fern conservation depends on our having sufficient knowledge about their ecology, distribution and conservation-status as well as having correct priorities for conservation with an approach giving due consideration to a combination of species and their habitats. Effective conservation management can be ensured by a combination of *in-situ* conservation of the habitat and in certain cases *ex-situ* conservation by propagation from spores which must then be combined with re-introduction. Public education and the participation of local people in conservation activity will also help guarantee the implementation of these programs.

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ASPLENIUM ×VOGELII (*ASPLENIUM AZORICUM* × *A. TRICHOMANES* SUBSP. *QUADRIVALENS*) (ASPLENIACEAE) A NEW ENDEMIC HYBRID SPLEENWORT FROM THE AZORES AND THE RELATIONSHIP AND ORIGINS OF ITS ENDEMIC PARENT, *A. AZORICUM*.

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Keywords: Chloroplast DNA, hybridisation, Macaronesia, pteridophyte, Terceira

ABSTRACT

The hybrid *Asplenium azoricum* × *A. trichomanes* subsp. *quadrivalens* is reported for the first time and described here as *A.* ×*vogelii*. Chloroplast DNA sequences are utilised to identify the maternal parent and provide further information on the relationships and possible origin of its endemic parent, *A. azoricum*. While definitely known only from the type gathering, collected near Terra Chã, Terceira in 1996, there is considerable potential for this hybrid to be overlooked owing to the similarity and variability of its parents.

INTRODUCTION

Asplenium trichomanes L. is an aggregate species of world-wide distribution, known to exist as diploid, tetraploid and hexaploid cytotypes, all of which occur in Macaronesia (Lovis, 1964; Gibby & Lovis, 1989; Sánchez Velázquez, 2006). However, within the Azores only the common and cosmopolitan tetraploid *A. trichomanes* subsp. *quadrivalens* D.E. Mey. has been conclusively reported (Silva et al., 2010; cf. Carvalho e Vasconcellos, 1968 who incorrectly suggested diploids were also present). This tetraploid taxon is almost exclusively associated with built structures on the more populous islands, which suggests it is a naturalised introduction. The most frequent and widely distributed simply-pinnate spleenwort in the Azores has been shown to be a distinct endemic, *A. azoricum* Lovis et al. (1977: 88) (Rumsey et al., 2004). Mature plants of *A. azoricum* are very striking and unmistakeable, achieving a size never matched by *A. trichomanes*. The proportionately longer, narrower, more triangular and crenate pinnae and glossy sheen of *A. azoricum* readily distinguish it from *A. trichomanes*. However, plants of *A. azoricum* growing on exposed walls rarely achieve the stature shown by those in more "natural" sheltered forest floor habitats. Characters such as pinna shape, dentation and even surface appearance are less well developed and, as a consequence, separation from *A. trichomanes* becomes more problematic. Earlier authors, e.g. Drouet (1866), Milde (1867) and Trelease (1897) regarded these Azorean plants as a distinct form of *Asplenium anceps* Lowe ex Hooker & Greville in Hooker, a Macaronesian endemic diploid (Rasbach et al., 1981), described originally from Madeira and known

also from Teneriffe, La Gomera, El Hierro and La Palma, Canary Islands (Vanderpoorten, Rumsey & Carine, 2007). The nearest relative to *A. anceps* on morphological grounds would appear to be the Asiatic *A. tripteropus* Nakai which differs mainly in its consistently proliferous nature; it is also known as a tetraploid (Wang, 1989). Two plants of *A. anceps* were collected on the Azorean island of Pico in 1973 (Lovis et al., 1977) but it has never been re-found here, or elsewhere on the archipelago. While probably best regarded as a chance colonist, the presence of this species here is tantalising, given its potential ancestral relationship to the Azorean endemic (see discussion below). Lovis et al. (1977) linked *A. azoricum* not to *A. anceps* but to the Neotropical *A. heterochroum* Kunze. In spite of considerable similarities between these two taxa, they considered there were sufficient consistent morphological differences to warrant its recognition as a distinct species; however, this remained to be tested by molecular methods. As *A. heterochroum* was known only as tetraploid and hexaploid cytotypes, Lovis *et al.*, (1977) also considered it an unlikely progenitor of the tetraploid Azorean plant.

The cytological study of hybrids has proven a useful tool in elucidating the complex evolutionary history of many polyploid fern lineages (eg. Lovis, 1977). The pattern of chromosome pairing in the artificially created triploid hybrid between *A. anceps* (diploid) and *A. azoricum* (tetraploid), taken with evidence from another naturally occurring *A. azoricum* hybrid, that with *A. onopteris* L., indicated considerable genomic homology between them, suggesting *A. anceps* to be part-parental to *A. azoricum* (Rumsey et al., 2004). Allozymic studies (Vogel, unpubl.) were, however, far more equivocal. The relationship as evidenced by other molecular markers remains to be tested.

Like *A. anceps*, *A. azoricum* typically has a strong glossy sheen; however, it lacks the diagnostic pronounced ventral wing to the rachis of *A. anceps*. This feature is also present, if in reduced form, in the allo-hexaploid *A. trichomanes* subsp. *maderense* Gibby & Lovis, a rare taxon derived through polyploidy following hybridisation between *A. anceps* and *A. trichomanes* subsp. *quadrivalens,* described from high altitudes in Madeira (Gibby & Lovis, 1989) but now also known to be present in the mountains of La Palma, Canary Islands (Sánchez Velázquez, 2006).

To date very few hybrids involving these simply pinnate *Asplenium* species have been reported within the Azores; those which have: *A.* ×*diasii* H. Schaef., F.J.Rumsey & H.Rasbach (*A. onopteris* × *A. azoricum*) and *A.* ×*santamariae* H.Schaef., F.J.Rumsey & H.Rasbach (*A. scolopendrium* × *A. azoricum*) are currently known only from the oldest, easternmost island of Santa Maria (Rumsey et al., 2004). Although involved in at least 12 interspecific and numerous intra-specific hybrids in Europe and the more southern Macaronesian islands, no hybrids of *A. trichomanes* had been reported in the Azores prior to this study. The directionality of the hybrid formation in these rare hybrids has been established through the identification of the maternal lineages of hybrid individuals by sequencing of regions of the plastid genome, which is maternally inherited in this genus (Vogel et al., 1998). This technique can aid identification of hybrid parentage where this is uncertain on morphological grounds but can also help in our understanding of the processes that may promote or control hybridisation success, a major factor in plant speciation.

Lovis et al. (1977), and others subsequently, have actively sought the hybrid between *A. azoricum* and *A. trichomanes* subsp. *quadrivalens* but failed to detect it. It was thus with some satisfaction that Johannes Vogel and the first author (Fred Rumsey) finally located this hybrid while making general fern collections on the islands in 1996.

The continuing development of molecular techniques now allows us to determine both

the direction of hybridisation and also to look again at the relationships and origins of the simply-pinnate Macaronesian spleenworts. On the back of an innovative teaching programme for school children that combined field skills with molecular approaches (Hopkins & James, 2010), a study was commenced to establish the utility and accuracy of the chosen universal DNA barcoding markers for the British and Irish fern flora (De Vere et al. 2012), into which were incorporated some related and critical taxa including *A. azoricum* and the new hybrid.

In this paper, we first describe the new hybrid and then present molecular insights into its parentage.

TAXONOMY

Asplenium ×vogelii F.J.Rumsey, Hendy & K.E.Jones *hybr. nov.* (*Asplenium azoricum* Lovis, Rasbach & Reichstein ×*A. trichomanes* L. subsp. *quadrivalens* D.E.Mey.)

Holotypus: PORTUGAL. Azores: Terceira, Terra Chã, on rocky roadside bank, 26th September 1996, *J.C. Vogel & F.J. Rumsey 96-9-26-1* (BM).

Hybrid, intermediate between parents (see Figure1) and chiefly differing from them both in its sterility, forming only blackish, malformed spores. From *A. azoricum* it differs in its more matt colouration, the less crenate, rather less tapering and less auriculate pinnae and from *A. trichomanes* subsp. *quadrivalens* by its more distinctly biauriculate lower pinnae, the proportionately narrower and more triangular pinnae and the short, stout, rather fragile rachis.

Rhizome short, erect, the apex covered with scales. Stipe short, 1-2cm long, c. 1mm thick, scaly at base but glabrous above, rather brittle, chestnut brown, bordered each side by a paler wing, 0.1-0.4mm wide. Rhizome and rachis scales c. 5mm long, clathrate, appearing blackish-brown due to broad dark central stripe. Fertile fronds to c. 22cm long, 12-20mm wide, widest near the middle, once pinnate with up to 47 pairs of somewhat crowded partly overlapping to distinct, shortly petiolulate to subsessile, opposite to partly alternate, oblong-ovate to somewhat triangular lateral pinnae, the largest from 6-9(10)mm long by 2.5-5mm wide, the terminal small. Pinnae from c. mid leaf down acroscopically auriculate at the base, those in the lower third of the frond usually also basiscopically auriculate, pinnae margins plane to obscurely crenate-dentate; sori (1)2-6 pairs, the indusium palish, slightly erose at the margin.

Etymology: the name honours Dr Johannes Chr. Vogel, now director of the Berlin Natural History Museum, who first detected the plant and whose genetic and molecular studies have done much to elucidate the taxonomy and relationships within this genus.

Although both parental taxa can achieve larger size than the type gathering of *A. ×vogelii* (Figure1), in the context of where it occurred clear hybrid vigour was apparent, the plant size exceeding those of its nearest parental plants. The combination of vigour, intermediacy and a local intermixture of the parental taxa should provide an indication of the hybrid which can then be confirmed by its sterility; the spores blackened, misshapen and abortive. Morphologically it is most similar to *Asplenium trichomanes* subsp. *coriaceifolium* Rasbach et al. (1990: 471; syn. *A. azomanes* Rosselló et al. (1991: 115)) a fertile tetraploid known from the Balearic Islands, southern Spain and the

mountains of North Africa (Rumsey & Vogel, 1996), from which it can be distinguished by its sterility.

We assume the hybrid to be tetraploid because of its morphological intermediacy and the lack of any clear indication of other gene dosage effects from allozyme electrophoresis (Vogel, unpubl.) which might indicate it resulted from the union of an unreduced gamete with a normal one. Confirmation from cytology or through other cytometric means would however be desirable.

MOLECULAR METHODS

DNA extraction, PCR amplification and sequencing

FIGURE 1. Fronds of *Asplenium* ×*vogelii* and its parental taxa. (A) *Asplenium trichomanes* subsp. *quadrivalens* – Pico, *F.J. Rumsey & J.C. Vogel 96-10-4-2* (B) *Asplenium* ×*vogelii* – *Terceira, F.J. Rumsey & J.C. Vogel 96-9-26-1* (Holotype) (C) *Asplenium azoricum* – Flores, *F.J. Rumsey & J.C. Vogel 96-10-1-7*

DNA was extracted from ca. 0.1g of silica gel-dried material from one specimen of *A. azoricum* (PT355) and one specimen of *A.* ×*vogelii* (PT351 = FJR & JCV 96-9-26-1) using a modified hexadecyltrimethylammonium bromide (CTAB) extraction protocol (Doyle & Doyle 1987) in which the aqueous phase from chloroform precipitation was cleaned using DNeasy spin columns (Qiagen, Manchester, UK). PCRs were conducted using a Techgene Thermal Cycler (Techne, Cambridge, UK). The *rbc*L region was amplified using the universal rbcL*a-f* primers (Kress & Erickson, 2007). PCRs were carried out with the following conditions: initial denaturation at 94ºC for 30 seconds and 35 cycles: 94ºC for 30 seconds, 55ºC for one minute and 72ºC for one minute, followed by a final extension at 72ºC for 10 minutes. PCR products were cleaned using Millipore plates (Millipore, Massachusetts, USA). Dideoxycycle sequencing (28 cycles: 30 seconds of denaturation at 95ºC, 15 seconds of annealing at 50ºC, 4 minutes of extension at 60ºC) with big dye terminators was performed in 10µl volumes using a Hyaid Omnigene Thermal Cycler and the PCR primers. DNA fragments were separated using capillary electrophoresis on an ABI 3730xl sequencer. We obtained sequences from genbank for the following taxa: *A. anceps* (AY300105.1), *A. heterochroum* (AY549745.1) and *A. trichomanes* (AY283236.1). Sequences were edited and assembled in Sequencher v. 5.2.4 and then manually aligned to visualise the sequence variation in MEGA 6.06.

Molecular results

According to rbcL sequence data *A.* ×*vogelii* and *A. azoricum* exhibited identical sequences, and *A. trichomanes* was distinct by two base pairs from these two taxa.

We therefore conclude that the maternal parent of *A.* ×*vogelii* is *A. azoricum*. *Asplenium anceps* also shares a rbcL sequence with *A.* ×*vogelii* and *A. azoricum,* supporting the cytological evidence of genomic homology and furthermore suggesting that it was the maternal parent in the original hybridisation event which formed the progenitor of the allopolyploid *A. azoricum*. *Asplenium heterochroum,* originally proposed as the most morphologically similar taxon (Lovis et al., 1977), is molecularly more divergent from all other taxa in this study (nine base pairs distinct from the *A.* ×*vogelii, A. azoricum* and *A. anceps* group and 10 base pairs distinct from *A. trichomanes*). Therefore, despite its considerable morphological similarity, it can be excluded from consideration as a close relative, or as progenitor, at least as maternal parent.

DISCUSSION

While quite possibly overlooked, we believe the hybrid, *A.* ×*vogelii* to be genuinely uncommon in the Azorean islands. The parental taxa do occur together on the majority of the Azorean islands and yet the hybrid has only definitely been found once. *Asplenium trichomanes* subsp. *quadrivalens* appears almost exclusively on built structures within the Azores. If a neophyte, as this habitat preference might indicate, its arrival to the Azorean islands is not easy to estimate due to the earlier confusion with *A. azoricum*. Surprisingly, the earliest Azorean specimen at BM dates from as recently as 1963. The taxon's tendency to occur more regularly on lime-mortared stone structures (e.g. houses, bridges and some roadside walls), where greater strength than a dry-stone technique is required, may be explained by a strong calcicolous requirement not met by the majority of the naturally occurring volcanic rocks, or their derived soils. Strangely, the most calcareous of the Azorean islands, Santa Maria in the eastern group, supports very little *A. trichomanes* subsp. *quadrivalens*, its niche generally occupied by *A. azoricum* which

is particularly abundant there. Likewise the westernmost islands of Flores and Corvo have respectively, little, or no *A. trichomanes* subsp. *quadrivalens* (Rumsey & Schäfer, in prep.). It is in the most populous and urban islands of São Miguel in the east and Faial (Schäfer, 2001) and Terceira in the central group where *A. trichomanes* subsp. *quadrivalens* achieves greatest abundance. Here on walls in rocky situations it most regularly co-exists with the native endemic *A. azoricum*. The nature of this habitat, with disturbance and exposure that promote turnover and recruitment opportunities, is known to be associated with hybridisation in the genus (Jee, 1994; Rumsey *et al.*, 2004). If it is a comparatively recent colonist then the length of time over which the two taxa have been sympatric is short, perhaps limiting the opportunities for hybridisation, which may account in part for the apparent rarity of the hybrid and the lack of any other hybrids involving this species.

The breeding system of *A. azoricum* is unknown; *A. trichomanes* subsp. *quadrivalens* has been demonstrated to be strongly inbreeding (Suter, Schneller & Vogel, 2000), as are many polyploid *Asplenium* species (Vogel et al., 1999; Trewick et al., 2002). In contrast to the present study, in previously studied hybrids of *A. azoricum* (*A.* ×*santamariae* and *A.* ×*diasii*), *A. azoricum* was shown to be the paternal parent (Rumsey et al., 2004), the maternal parents being the diploid and more generally outbreeding taxa. We might predict that, all other factors being equal, the more strongly inbreeding taxa would be less likely to be maternal parents as they routinely, rapidly self-fertilise but their antherozoids, potentially produced over a longer period, would enable them to fertilise more outbreeding taxa.

Within the Pteridophyta tetraploid hybrids, such as we believe *A.* ×*vogelii* to be, are generally less frequent than triploid hybrids, presumably largely as a consequence of the respective breeding systems of the parental taxa. Other factors relating to gametophyte ecology, phenology and response to antheridiogens, as well as phylogenetic relatedness of the parents also undoubtedly contribute to the success, or failure, of hybrid formation and subsequent growth. Given the major role that this mechanism has played in plant evolution and speciation it is still remarkably understudied.

The discovery that *A. azoricum* is identical to the Macaronesian endemic diploid *A. anceps* according to the plastid marker, *rbc*L, helps clarify one lineage in this allo-tetraploid, but the other parent still remains unclear and its geographical origin is also problematic. Other than *A. anceps*, itself only known from a single reported 20th century occurrence, there are no known diploid simply-pinnate taxa native to the Azores. *Asplenium anceps* is currently sympatric with a simply pinnate diploid only on La Palma in the Canaries where *A. trichomanes* subsp. *trichomanes* is rare and was overlooked until reported by Sánchez Velázquez (2006). While this is thus the most plausible candidate for the missing parent, on purely morphological grounds it lacks many characters one would predict to be present assuming intermediacy in the ancestral hybrid (cf. Rasbach, Rasbach & Viane, 1989). There exist a few instances of narrow endemic Macaronesian polyploid ferns that no longer co-occur with both parents, yet the missing parent taxa still occur elsewhere in Macaronesia. For example, the Canarian/Iberian *Dryopteris guanchica* Gibby & Jermy is derived from the Madeiran endemic *D. maderensis* Alston (Gibby et al., 1977; Gibby, 1983). This would indicate the possibility of local losses and extinctions and past mobility between the Macaronesian archipelagos; limited palaeo-ecological evidence clearly suggests very different communities were present, at least on the Canaries (De Nascimento et al., 2009). While predominantly European in its affinities the terrestrial cryptogamic flora of the Azores does show a small

but significant neo-tropical component (Vanderpoorten et al., 2007; Rumsey et al., 2014). However, the contribution of *A. anceps* would seem to preclude an origin of *A. azoricum* outside of Macaronesia. Further studies on a wider range of Neotropical and Afro-montane species using bi-parentally inherited nuclear markers may now be necessary to throw more light on the relationships and origins of these taxa.

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TAXONOMIC AND NOMENCLATURAL NOTES ON PHILIPPINE FERNS. III. *ASPLENIUM CAUDATUM* (ASPLENIACEAE) AND FERNS CONFUSED WITH IT

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Key words: *Asplenium caudatum*, *Asplenium truncatilobum*, *Asplenium truncatum*, *Asplenium horridum*, Philippine ferns, Polynesian ferns.

ABSTRACT

The confused taxonomy of *Asplenium caudatum*, *A. truncatilobum*, *A. truncatum* and *A. horridum* is discussed. Data supporting their retention as separate species are presented and their nomenclatural histories reviewed. *Asplenium caudatum* is restricted to Tahiti; *A. truncatum* to the Malay Peninsula and the Western Sunda Islands; *A. truncatilobum* is a Philippine endemic found in central and northern Luzon; and *A. horridum* is a common fern of Hawaii, Samoa, Tahiti, and the Cook, Marquesa and Austral Islands.

INTRODUCTION

The taxonomy of *Asplenium caudatum* G.Forst. has been confused since the early 19th century. The variability of the species, incomplete descriptions, lack of material from Polynesia and poor communication plagued early botanists. These early authors treated *A. caudatum* and related species in different ways, sometimes erroneously, and some of their errors have been perpetuated to the present. As many as six Malesian species have been confused with *A. caudatum*. The confusion between *A. caudatum*, *A. anisodontum* C.Presl, *A. longissimum* Blume and *A. acutiusculum* Blume has already been clarified. (Salgado, 1996). A survey of the specimens identified as *Asplenium caudatum* found at B, BM, K, L, NY, P, S, UPS, US and W revealed that *A. truncatilobum* (C.Presl) Fée, *A. truncatum* Blume and *A. horridum* Kaulf. have traditionally been confused with *A. caudatum*. For the purpose of this study, extensive material and the types or isotypes of *Asplenium caudatum* (BM!, LIV!, S!; photos GOET, MW, UPS), *A. truncatilobum* (BM!, B!, K!, L!, P!, PRC!, UPS!, US!), and *A. truncatum* (L!, BM!), have been examined. The author did not study the type of *horridum*, which is presumably found in LE. There is, however, a Chamisso specimen from Oahu, Hawaii, at PRC with two labels in Presl's handwriting: "*Asplenium caudatum* Forst. *Asplenium horridum* Kaulf."; and the other label: "*Asplenium horridum* Kaulf. O-Wahu. Chamisso." This PRC specimen should be considered an isotype. Data are presented in this paper that will clarify the differences between *A. truncatilobum*, *A. truncatum*, *A. horridum* and *A. caudatum*. The characters in the following key distinguish these species.

KEY TO THE SPECIES

1. Lamina base truncate; rachis proliferous .....*A. truncatum.*
1. Lamina base gradually reducing; rachis not proliferous 2
2. Frond width (4-)5-8(-9) cm; acroscopic basal pinna lobe much larger than other lobes, very distinct, usually square in overall appearance, lobe apex truncate, finely serrate,

with a notch .....*A. truncatilobum.*

2. Frond width (12-)14-26(-23) cm; acroscopic basal pinna lobe similar or slightly larger than the rest, not very distinct from other lobes, oblong or rounded in overall appearance, lobe apex irregularly truncate and variable, crenate or irregularly toothed, notch absent 3
3. Stipe and rachis scaly or glabrescent, scales up to 5 mm; lobes closely approximate, with narrow sinuses about halfway down to the costa, costa and veinlets with a few scales on the abaxial side of the lamina; first line of sori oblique and near or not to the costa.....*A. caudatum.*
3. Stipe profusely scaly, scales up to 15 mm long; lobes distant, with wide sinuses cut down close to the costa, costa and veinlets with many reduced scales on both sides of the lamina; first line of sori parallel and near the costa.....*A. horridum.*

DISCUSSION

Asplenium truncatum Blume

Asplenium truncatum Blume var. *lobulatum* Blume, Enum. Pl. Javae 184, 1828. — TYPE: Java, *Blume s. n.* [Herb. Lugd. Bat. 908,309—477] and [Herb. Lugd. Bat. 908,309—478], (BM!, L!). *Asplenium truncatum* Blume var. *crenulatum* Blume, Enum. Pl. Javae 184, 1828. — TYPE: Java, *Zippelius s. n.* (L!).

After Blume's (1828) original publication of the species and its two varieties (Figure. 1), authors either did not mention *A. truncatum* (Presl, 1836, 1851; Fée, 1850-1852; Raciborski, 1898; Alderwerelt, 1908) or reduced it to a synonym of either *A. horridum* (Mettenius, 1859; Hooker, 1860; Moore, 1860) or *A. caudatum* (Mettenius, 1865-1866; Christensen, 1906; Backer & Posthumus, 1939). Except for the original description, the author has not found in the literature any reference to *A. truncatum* as a species. *Asplenium truncatum* Blume was accepted as a species for a short time and was forgotten once reduced to synonymy.

Asplenium truncatum Blume is readily distinguished from *A. caudatum, A. horridum* and *A. truncatilobum* by its truncate lamina base and prolific rachis (Figure 1). Additional characters that distinguish *A. truncatum* from *A. caudatum* are the parallel rows of imbricate sori very close to the costa, the wide and very reduced branched scales of the stipe and rachis, and the deep marginal sinuses of the pinnae. *Asplenium truncatum* is much less scaly than the hirsute *A. horridum* and *A. truncatilobum*. Like *A. horridum, A. truncatum* has parallel sori contiguous to the costa, but the sori are often - but not always - imbricate and their distal end bends toward the lobe. In *A. horridum* the sori are straight and do not imbricate. Besides not being hirsute, *A. truncatum* differs from *A. truncatilobum* in the shape of the acroscopic basal lobe of the pinna, and the deep and narrow sinuses of its pinnae.

Asplenium truncatum is well represented in herbaria, usually under the name *A. caudatum*. It has been collected numerous times in the mountains of Java between 1000 and 2600 m, and less often in the Malay Peninsula, Sumatra, Borneo, Celebes, and Bali. The author has not found a typical *A. truncatum* in the Philippines, Lombok, eastern Sunda Islands, Moluccas, and New Guinea.

SELECTED SPECIMENS EXAMINED: **MALAYSIA**. **Perak State:** Thaipuis (?), 1890, *H. N. Ridley 1870* (BM); Gunung Hijau, Taiping, 6 Feb. 1908, *C. G. Mathew s. n.* (K); Perak, 1911, *Scortechini 473* (K); Lungei Burong, Cameron Highlands, Pahang, 5000 ft, 20 May 1936, *Holttum 31356* (K); Fraser Hill, Pahang, 4100 ft, 10 Aug. 1939,

Figure 1. *Asplenium truncatum* Blume, (*C. Holstvoogd s.n.,* L). Note the truncate lamina base and proliferous rachis near the lamina apex.

G. H. Addison 37202 (K); Birch's Hill, Maxwell's Hill, 3738-4100 ft., 9 Sep. 1949, *Sinclair & Kiah 38647* (BM, K); on mossy tree trunk in dense forest, route from Tanah Rata to Gunong Beremban, Pahang, 1500-1800 m, 18 Oct. 1967, *T. Shimizu, K. Iwatsuki, N. Fukuoka & M. Hutoh 13259* (L); disturbed oak-laurel forest, terrestrial, sometimes epiphytic, common, Cameron Highlands, Pahang, Gunong Berinchang, 1550m, 21 Jun. 1975, *van Balgooy 2671* (L); growing on boulder in shade, Gunung Telapak Burok, Negeri Sembilan, 3900 ft, 28 Mar. 1976, *A. G. Piggott 1672* (K); fallen epiphyte in clump of Asplenium nidus, locally common, Cameron Highlands, Pahang, Gunong Beremban, 1660 m, 11 Aug. 1986, *B. S. Parris 10915* (K, L). **INDONESIA. JAVA**: **West Java Province (Djawa Barat):** ex herbario Blume, volcan Gedeh, 1867, *Blume s. n.* (P); ex herbario Blume, volcan Gedeh, 3000 – 5000 ft, 1867, *Blume s. n.* (P); Pangerango, 2500 m, 5 May, 1875. *Herb. Otto Kunze 4666* (NY); Preanger, "in silva primaeva infra craterem", Kawah Manuk, alt. 1750 m, 2 Dec. 1894, *V. Schiffner s. n.* (K, L); Mt. Gedeh, Tjibodas, Feb. 1904, *F. Ramaley 505* (US); prés de Kandang Badak dans la source chaude, Mt. Gede, 2100 m, 22 Apr. 1904, *B. P. G. Hochreutiner 2044* (L); Oct. 1904, *B. P. G. Hochreuteiner 2044* (L); Tjiboeroem, forested middle slopes of Mount Gede, alt. 1660 m, 12 April 1909, *W. Palmer & O. Bryant 166* (US, 651589, 651590 and 65159); in clumps on trunk, drooping, alt. 1700 m, 14 August, 1909, *W. Palmer & O. Bryant 782* (US, 652285 and 652286); hanging from a large tree, alt. 1500 m, 15 April 1909, *W. Palmer & O. Bryant 201* (US); on base of trunk drooping, alt. 1700 m, 21 April 1909, *W. Palmer & O. Bryant 860* (L, US); on tree trunks, Tjiboeroem, forested middle slopes of Mount Gedeh, alt.1700 m, 23 April, 1909, *W. Palmer & O. Bryant 258* (US); on tree exposed, alt. 1600 m, April 24, 1909, *W. Palmer & O. Bryant 296* (US); on trunk, alt. 1600 m. August 16 1909, *W. Palmer & O. Bryant 797* (US); vicinity of Kadang Badak, Mt. Gede, 2600 m, 24 Aug. 1909, *W. Palmer & O. Bryant 924* (L, US); Tjibodas, 2000 m, 19 Nov. 1909, *H. Winkler 1877* (BM); [Rosenstock No. 2387], 1915, *Raciborski s. n.* (K, L); Sitoe Lembang, Boerangrang, Preanger, 1600 m, 4 Jul. 1920, *Balchuizen v. d. Brink 4548* (L); mossy forest, Kadang Badak, Java, alt.. 2400, March 1928, *H. S. Yates 2696* (NY, US); between Tjibodas and Tjibeureum, Mt. Gede, Java, 1400-1500m, 8 Dec. 1925. *B. H. Danser 5851* (L); Tjibodas, May 1937, *P.J. Eyma 65* (L); 3 Mar. 1940, *Holstvoogd 358* (BM, L); Sitoe Lembang, 9 Nov. 1941, *C. Holstvoogd 631* (L); Tangkoeban Prahoe, 14 Sep. 1941, *C. Holstvoogd 640* (L); height 50 to 60 cm, stalk black, Rawa Denok, alt. 1700 m, 26 May 1948, *Main 217* (L, US); Tjibeureum, 1600 m, 28 May 1948, *De Pleyte 198* (L); near Rawah Gajonggong above Tjibodas, in moist forest, 1 April, 1950, *S. J. van Ooststroom 13463* (US); from the ground close to the path, Hutan Kiara, Tjibeureum, alt. 1450 m, 23 Nov. 1955, *Temp. No. 35* (US); developing frond from same rhizome as other sheet, Hutan Kiara, 23 Nov. 1955. *Temp. No. 35* (US); in shade, epiphytic on mossy tree trunks, Tjibodas, 1500 m, 6 Sep. 1969, *Eddy, Jermy & Walker 7029* (BM); in rain forest, ca. 1500-2000 m, 26 Jul., 1981, *H. Okada 3554* (NY); terrestrial, rhizome upright, 15 cm long, along path to Cibeureum waterfall, Cibodas, 1400 m, 5 Apr. 1984, *A. J. M. Leeuwenberg 13208* (L); Gunung Prahu, *Horsfield 77* (BM); Pelaboean Ratoe, *Boerlage s. n.* (L, Herb. Lugd. Bat. 908317,236), *Boerlage s.n.* (L; Herb. Lugd. Bat. 908317,237). [Rosenstock #2386], 1915, *Hallier 466* (L); [Rosenstock #19446], 1922, *Hallier 466* (L); Mt. Hanang, *Horsfield s. n.* (BM). **Central Java Province (Djawa Tengah):** Gunung Slamat, 29 May 1898, *Raciborski s. n.* (L, US); Res. Madioen, Lawoe, 1200-1500 m, 1907, *J. Elbert 90* (L); Tawang Manggu, Gunung Lawu, 11 Aug. 1974, *S. Yoshida 1817* (L). **East Java Province (Djawa Timur)**: Southeast Java, 1880, *H. O. Forbes 860* (BM); Southeast

Java, 1880, *H. O. Forbes 1033* (BM); Southeast Java, Malawar, 6500 ft., 1880, *H. O. Forbes s. n.* (BM); Gunung Guntur, in herb. Racib. indetem., 15 Mar., 1897-98, *Raciborski s. n.* (US); Gunong Klantang, 23 Jun.,1897-98, *Raciborski s. n.* (K, L, US); Gunung Bentjana, 15 Jul., 1897-99, *Raciborski s. n.* (US); Gunong Papandajan, below the crater, from Villa Paulina and summit, alt. 4000 ft; common in jungle, terrestrial, 21 May,1915, *C. J. Brooks J35* (BM); Tengger Mountains: 1200 m, Jul. 1909, *Mousset s. n.* (US); 1200 m, Jan. 1910, *Mousset 79.* (BM, P, US, 2986967 and 2986968); Environs de Lawang, 1290 m, 2 Feb. 1909, *Mousset 43* (P); Aug. 1910, *Mousset s. n.* (K); [Rosenstock Fil. Jav. No. 79, Herb. Lugd. Bat. 910,211-845]; *Mousset s. n.* (L); [Rosenstock Fil. Jav. No. 79, Herb. Lugd. Bat. 910,211-871]; *Mousset s. n.* (L); Gunong Bareng, 2000m, 15 May 1932, *Clason-Laarman s. n.* (L); Southeast Java, 1880, *H. O. Forbes 860* (BM, L); Southeast Java, 1880, *H. O. Forbes 1033* (BM). **Sumatra**: Sibolangit, 1350 m, 17 Aug. 1918, *J. A. Lorzing 5932* (L); Brastagi, alt. 5000, 29 May 1923, *H. S. Yates 536* (US); Mt. Sibajak, North Sumatra, 1300 m, primary forest, epiphytic on stumps near the ground, not rare, 5 Feb. 1929, *J. A. Lorzing 15119* (L, US); on mossy trunk, in evergreen mossy forest, Atjeh, higher elevation of Gunong Kemiri, 1800-2500 m, 23 Aug. 1971, *Iwatsuki, Murata, Dransfield & Saerudin 1015* (L); primary forest, terrestrial, 30 cm tall, Gunong Sinambung, 12 Dec. 1975, *J. Mogea 540* (L). **Celebes (Sulawesi)**: Malakadji, in earth on stream bank in deep shade, 1000 m, 23 Jan. 1925, *E. Smith 2497* (K); Lombasang, NW Celebes, 950 m, 25 Apr. 1921, *Bunnemeijer 11170* (K). **Bali**: 6 km below Kintamani towards Singaradja, 18 Jun. 1976, *W. Meijer 10435* (US); montane forest, ca. 6 km WNW of Bedugul, above Kebun Raya, Tabanan, Central Bali, 1850 m, 25 Jul. 1994, *McDonald & Ismail 4870* (L). **Without definite locality in Java**: "*Asplenium truncatum*", Java, 1836, *Blume s. n.* (P); Java, as *Asplenium rostratum* [Herb. Lugd. Bat. 908,309 487] *Blume 28* (L); ['*Asplenium caudatum* Forst. f. *prolongatum*', Herb. Lugd. Bat. 908,309—460], *Blume s. n.* (L); [Rosenstock #2624, 1915], *Blume s. n.* (L); as *Asplenium longifolium*, Java, *Zipp. 202* (L); as *Asplenium longifolium*, Java, *Zipp. s. n.* (L); [Rosenstock 2399, *Korth 27* (US); Java, 1866, *Herb. P. V. LeRoy s. n.* (NY); Java, 1869, *Herb. A. Vigener s. n.* (NY); "Donné par M. de Vriese en Octobre 1851," Insulae Javae, *de Vriese 139* (P).

Asplenium truncatilobum (C.Presl) Fée

Tarachia truncatiloba C.Presl, Abh. Kön. Böhm. Ges. Wiss. ser. 5, v. 6, 437 (reprint as Epim. Bot., p. 77). 1851. — TYPE: Philippines: Luzon, *Cuming 99* (PRC!, isotypes US!, BM!, B!, K!, L!, NY!, P!, S!, UPS!).

Over the years, authors have treated *A. truncatilobum* in different ways. Presl (1851) created the genus *Tarachia* based on the arrangement of the sori to include species that he considered intermediate between *Asplenium*, *Diplazium* and *Scolopendrium* (Figure 2). He described *Tarachia truncatiloba* (1851) and transferred *A. caudatum* as *Tarachia caudata* (1851). Upon closer examination of soral characters, Fée (1850-1852) rejected the genus *Tarachia* and transferred all the species to *Asplenium*. Fée (1850-1852) maintained the separation between *A. truncatilobum*, a Philippine species, and *A. caudatum*, a Polynesian species. Mettenius (1859) ignored Fée's treatment of *A. truncatilobum* and reduced it to a synonym of *A. caudatum*. Hooker (1860), Moore (1860), Christensen (1906, 1913) and Alderwerelt (1908) followed this decision. Christ (1907), however, disagreed and kept *A. truncatilobum* separate from *A. caudatum*. Christensen (1933), in a change of mind, listed *A. truncatilobum* among the Mount Pinatubo ferns with the comment: "here belongs Copeland Pteridophyta Philipp. Exsicc.

No. 98 distributed as *A. caudatum* Forst." Copeland (1960) listed *A. truncatilobum* as a synonym of *A. caudatum*. Since Mettenius (1859), many herbaria have filed specimens of *A. truncatilobum* under the name *A. caudatum*.

Asplenium truncatilobum differs from *A. caudatum*, *A. horridum* and *A. truncatum* by the prominent acroscopic basal lobe of the pinnae (Figure 2). This lobe is formed by a deep and wide incision of the lamina and has the apex truncate, finely serrate and with an incision. *A. truncatilobum* can be further distinguished from *A. truncatum* by the reducing basal pinnae, non-proliferous rachis, and hirsute stipe and rachis; from *A. caudatum* by the parallel sori and hirsute stipe and rachis (Figure 2); and from *A. horridum* by the widely spaced, truncate pinna lobes.

Asplenium truncatilobum Presl is endemic in central and northern Luzon, Philippines. It is a terrestrial fern that grows in primary and secondary forests, from near sea level to 2000 m altitude, in regions with a pronounced dry season during part of the year.

SPECIMENS EXAMINED: **PHILIPPINES: Batangas Prov.**: Mt. Lobo, May 1952, *M. D. Sulit PNH 15759* (BM). **Benguet Prov.**: Baguio, on dry rocks, 19 Jan. – 26 Feb., 1903, *L. Topping 266* (US); Baguio, 17 Sep., 1904, *R. S. Williams 1517* (NY, US); Baguio, 28 Dec., 1907, *L. Topping 881* (US); About Twin Peaks, Benguet road, 12 Mar., 1908, *Paul Bartsch 235* (US); Trail between Baguio and Sablan, Luzon, 15 Mar., 1908, *Paul Bartsch 281* (US); Dec. 1908, *H. M. Curran & M. L. Merritt FB15726* (US); Dec. 1908, *H. M. Curran & M. L. Merritt FB15766* (US); Benguet, without specific locality, Dec. 1908, *Maximo Ramos BS 5773* (NY); May 1911, *Merrill 972* (PRC, US); Masman

Figure 2. *Asplenium truncatilobum* (C.Presl) Fée (*Cuming 99,* isotype, US). Acroscopic basal pinna lobe larger than other lobes, square in overall appearance, lobe apex truncate, finely serrate.

above Irisan, km 303 off Naguilian road, Jun. 1958, *Sinclair & Edaño 9769* (K, L). **Bontoc Prov**.: Mt. Masapilid, Mar. 1920, *Ramos & Edaño 37906* (L, US). **Bulacan Prov.**: Angat, Sep. 1913, *M. Ramos BS21711* (BM, L, US). **Cavite Prov.**: Cavite, *H. M. Curran 7669* (US). **Ifugao Prov.**: Mt. Data, 9 Apr. 1946, *G. L. Alcasid PNH 1756* (L). **Ilocos Norte Prov.**: Mt. Nagapatan, Aug. 1918, *M. Ramos 33189* (US). **Nueva Vizcaya Prov.**: Caraballo Sur, 28 May, 1902, *Merrill 295* (US). **Pampanga Prov.**: Mt. Arayat, 1800 m, Jun. 1896, *A. Loher 902* (P); Mt. Arayat, on dry rocks, 21 Feb., 1904, *L. Topping 477* (US); Mt. Arayat, May 1904, *Merrill 3816* (K, US); Mt. Arayat, Oct. 1904, *Merrill 3909* (K, NY, US); Mt. Arayat, Feb. 1984, *Salgado 797, Salgado 801* (K); Mt. Pinatubo, Camp Stotsenburg, May 1927, *Elmer 22026* (BM, L). **Quezon Prov.**: Sariaya, Tayabas, Aug. 1904, *H. N. Whitford 560* (K, NY, US). **Rizal Prov.**: Bosoboso, Jul. 1906, *Maximo Ramos BS1079* (NY, US); Bosoboso, Aug. 1907, *M. Ramos BS4632* (NY, P, US); Montalban dam, Nov. 1908, *Copeland 98* (BM, K); Dec. 1912, *J. Reillo BS19293* (US); fragment, without specific locality, Oct. 1913, *Loher 14499* (US). **Zambales Prov.**: Nov.-Dec. 1907, *Maximo Ramos BS4766* and *Maximo Ramos BS4793* (US); Mt. Irig, Feb. 1923, *M. Ramos BS41865* (US).

Asplenium caudatum G.Forst.

Asplenium caudatum G.Forst., Fl. Ins. Austr. Prod. 80, 1786. — Type: "Insulae Oceani Pacifici", Polynesia, *Forster s. n.* (isotypes BM!, LIV!; not seen, photo GOET, MW, UPS).

Georg Forster (1786) provided a short description of *Asplenium caudatum* but failed to provide enough diagnostic characters that would clearly distinguish *A. caudatum* from other species of similar appearance. The description is based on a specimen he collected in Polynesia at an unspecified location (Figures 3). Schkuhr (1809) states that it came from the Friendly Islands (Freundschaftsinseln), which is an old name for Tonga. Copeland (1932), however, interpreted Schkuhr's statement about the type locality as Tahiti, in the Society Islands. Christensen (1943) followed Copeland's interpretation. Nicolson & Fosberg (2004) state that Joseph Banks called Tahiti the Friendly Islands after his stay there for several months during Cook's second voyage to the Pacific.

The differences between *Asplenium caudatum* and the Malesian *A. truncatum* and *A. truncatilobum* have already been presented. *Asplenium horridum*, however, is more difficult to distinguish from *A. caudatum*. Skottsberg (1942) correctly remarks that the differences are not constant but "...as long as the stipe and rachis, which are more robust than in any *caudatum* that I have seen, are covered with the dense dark fur, *A. horridum* is easily known, and in Hawaii, where no typical *caudatum* has been found, it is very distinct" (Figures 3, 4, 5). Other characters that distinguish *A. caudatum* from *A. horridum* are the type of scales, the narrow sinuses, and the oblique sori. This combination of characters is consistent enough that the two species can be distinguished in the vast majority of cases. Specimens that are glabrous or glabrescent, with narrow marginal sinuses cut halfway down to the costa, and oblique or divergent sori must be assigned to *A. caudatum*.

It is worth noticing the paucity of specimens in herbaria that match the type of *A. caudatum*. The author has not found a single specimen from the Philippines or other parts of Malesia, nor from Tonga, Samoa, the Cook and Austral Islands, and Hawaii, that agrees with the type of *A. caudatum*. It has been reported only once in Fiji (Brownlie, 1977), epiphytic on a tree on the summit of Mt. Koroyanitu, in Viti Levu; the pinna margin outline and the soral arrangement shown in Brownlie (1977; Plate XXI, f. 4) are

Figure 3. *Asplenium caudatum* G.Forst. (*G. Forster s.n.*, isotype, BM.) Decreasing basal pinnae.

not typical of *A. caudatum*. It is doubtful that this plant belongs in *A. caudatum*. *Vieillard s. n.* (US), an ornamental plant collected in Tahiti last century, agrees with BM, LIV and MW isotypes in details of the pinnae and the arrangement of the sori. *D. Nelson s. n.* (BM), *Savatier 899* (K, P) from La Vallée de la Reine, Tahiti, *Florence & Jourdan 11075* (US) from the valley of the river Paho, Toahotu, Tahiti, *J. Nitta 570* (P) from the Moorea, Society Islands (Figure 4), and *E. Schuettpelz 1857* (P) from Ua Pou, Marquesas Islands also agree with these isotypes of *A. caudatum*. Forster evidently collected a rare species.

SPECIMENTS EXAMINED: **FRENCH POLYNESIA: SOCIETY ISLANDS: Tahiti:** 1 m de hauteur, montagnes, 800 m, 1847, *J. Lépine 73* (P); Herbier de Bory St. Vincent, 1847, without locality or collector (P); espèce dont les frondes attaignent près des 2 mètres de longueur, dans les vallées humide et élevés, 1847, *M. Vesco s. n.* (P); espèce assez rare, lieu élevés, 800 m, *Vesco s. n.* (P); Taïti, 1847, *M. Vesco s. n.* (four sheets, P); Herbier du R. P. Montrouzier, Tahiti, *Montrouzier 335* (P); Vallée de la rivière Paho, Toahotu, crête sud, alt. 650 m, 149°16'W, 17°47'S, *Florence & Jourdan 11075* (US); ornamental, *Vieillard s. n.* (US); Otaheiti, *D. Nelson s. n.* (BM); Insula Otaheite, *Barclay s. n.* (BM); arborescent, vers 1200 m, *Nadeaud s. n.* (P); Tahiti, Herbier E. Drake, *Savatier? s. n.* (two sheets, P); Isle de Tahiti, Herbier E. Drake, *Nadeaud s. n.* (P). **MARQUESAS ISLANDS**: Ua Pou. At base of Poumaka; 680 m; mid-elevation wet forest (dominated by Hibiscus and Metrosideros). On wet rock. 201-10-30, *E. Schuettpelz 1857* (P).

Asplenium horridum Kaulf.

Asplenium horridum Kaulf., Enum. Fil. 173, 1824. — TYPE: Hawaii: O-Wahu, *Chamisso s. n.* (PRC!, LE? not seen).

Kaulfuss (1824) recognized the similarity between *A. horridum* and *A. caudatum* but kept the two separate. Presl (1836; 1851) and Raciborski (1898) reduced *A. horridum* to a synonym of *A. caudatum,* while Mettenius (1859), Hooker (1860), Moore (1859), Christensen (1906), and Alderwerelt (1908) recognized it as a separate species. Christ (1894; 1895) published the name *A. caudatum* G.Forst. var. *horridum* for epiphytic plants growing in Celebes. He considered *A. horridum* a hairy variety of *A. caudatum* with a parallel row of non-diverging sori on each side of the costa (Christ, 1894; Figure 5. *Asplenium horridum* Kaulf. (*Otto Degener, K. Park & M. Takamoto 10164,* US.) Note the hirsute stipe and rachis.re 5). Reinecke (1897) used the name *A. caudatum* G.Forst. var. *horridum* for plants from Samoa. The author has not seen a true *A. caudatum* specimen from Samoa and presumes that Reinecke was referring to *A. horridum,* as it is construed here. Years later, however, Christ (1907) distinguished between *A. caudatum* and *A. horridum*. Hillebrand (1888) and Christensen (1943) commented that *A. horridum* was considered by most authors to be a larger, more deeply cut, and scalier form of *A. caudatum*. Copeland (1960) did not make any reference to *A. horridum*.

Asplenium horridum is similar to *A. caudatum* in appearance but is distinct from the latter in being hirsute, with a mixture of wide and reduced scales on the stipe and rachis (Figure 5). Some scales are black, forming a 15 mm long ribbon, about 6-cell wide above the base, with large cells whose margin has long hair-like projections, whose apex becomes a thick lash. In *A. caudatum,* the scale body is reduced to a thick hair-like structure. The other type of scales consists of a flat disk of cells adpressed to the rachis, with up to 5 marginal hair-like twisted projections, one of which is longer. These scales are mostly up to 3 mm long, but some may reach 15 mm in length. Brown and Brown

Figure 4. *Asplenium caudatum* G.Forst. (*E. Schuettpelz 1857*, P). Collected in 2017 on Ua Pou, Marquesas Islands.

(1931) used the differences in the abundance of scales to described four varieties from the Marquesas and Rapa.

Asplenium horridum also differs from *A. caudatum* in having the pinna margin with wide sinuses often as broad as the lobes, cut down close to the costa, and the sori parallel and near the costa. In *A. horridum*, the primary row of sori forms a straight row on each side of the costa and is contiguous to it, but the sori are not imbricate (Figure 5). The secondary veins and the wide sinuses determine the position of the sori. The secondary veins arise at an acute angle at the base of the preceding lobe; the adaxial branch of the first fork is parallel the costa as far as the outer margin of the next lobe, where it suddenly deflects toward the apex of the lobe. The sori are located at the base of the lobe, on the parallel portion of the vein and do not extend into the narrow laminar area under the sinus, thus leaving a gap between the sori. The widely spaced lobes and the deflection of the adaxial branch of the secondary veins into the lobes prevent the sori from overlapping. The sori are so close to the costa that the mature sporangia often cover the costa from both sides. These characters are variable in both species. A plant may show an intermediate condition in one or two of these characters, but when all of these features are considered together, it is possible to separate *A. caudatum* from *A. horridum*.

The reducing basal pinnae, the non-proliferous rachis, the abundance of scales and the straight row of non-imbricating sori distinguish *A. horridum* from *A. truncatum* (Figure 5; Figure 1). *A. truncatilobum* is hirsute with a mixture of wide and reduced scales on the stipe and rachis. *A. truncatilobum* has widely spaced lobes like *A. horridum*, but differs from the latter in its characteristic acroscopic basal lobe, which is large and rather square in shape, the imbricating sori, and in the pinnae having fewer, truncate lobes (Figure 2). *A. truncatilobum* is a smaller fern reaching up to 30-40(-60) cm, while *A. horridum* often reaches 100 cm or more.

Asplenium horridum is a common, epiphytic or terrestrial plant of the low altitude humid forests of Polynesia (up to 1600 m). It is often collected and is well represented in herbaria. *Asplenium horridum* is common in Hawaii, Fiji, Samoa, Tahiti, and the Cook, Marquesas, and Austral Islands. It is absent from Malesia as it is construed here (Figure 6). The author has not seen *A. horridum* in the Philippines, and Christ's (1907) report is puzzling. Copeland (1960) lists *A. horridum* as a synonym of *A. caudatum*.

Besides their different morphological characteristics, these four species have different geographic distribution (Figure 6). *Asplenium truncatilobum* is an endemic, terrestrial species found in the seasonally dry forests of central and northern Luzon, Philippines, from sea level to 2000 m. *Asplenium truncatum* is found in Sumatra, Java, Celebes, Bali, and Flores. It grows epiphytic or terrestrial in the wet mountain forests of these islands between 1000 and 2600 m. *Asplenium horridum* covers a trapezoidal area of Polynesia formed by Hawaii in the north corner of the trapezium, Fiji in the southwest corner, Rapa in the south and the Marquesas in the east corner. It grows in wet forest floor and rarely as an epiphyte on mountain slopes and ridges between 200 and 1500 m. *Asplenium caudatum*, as construed here, is an uncommon fern from Tahiti and the Marquesas (cf. Hillebrand, 1888; Brown & Brown, 1931), overlapping the territory of *A. horridum* in these islands. It is an epiphytic or terrestrial fern that grows in humid forest between 200 and 700 m.

SPECIMENS EXAMINED: **UNITED STATES: HAWAIIAN ISLANDS**: **Oahu:** Kaala Mountains, Sandwich Islands, 1838-1842, *U. S. Expl. Exp. Wilkes 28* (US); Sandwich Islands, 1838-1842, *U. S. Expl. Exp. Wilkes 28* (NY, US); Ins. Sandwich, Honolulu, Anno

1852, *N. Y. Anderson s. n.* (US); Oahu, Sandwich Islands, 1866, *Barclay s. n.* (BM); N. V. "Pa moho huluhulu", ridge between Manoa and Nuuanu valleys, 20 Dec., 1887, W. E. Safford 904 (US); N. V. "Pa moho huluhulu", ridge between Manoa and Nuuanu valleys, 20 Dec., 1887, *W. E. Safford 905* (US); Numauu Pali, Honolulu, Feb. 1907, *Copeland s. n.* (P); Waiolani Ridge, 10 Dec. 1908, *C. N. Forbes s. n.* (P); Mapaha Valley, Koola Range, 12-19 Feb. 1909, *C. N. Forbes s. n.* (P); Makawao, 800 m, Aug. 1909,

Figure 5. *Asplenium horridum* Kaulf. (*Otto Degener, K. Park & M. Takamoto 10164,* US.) Note the hirsute stipe and rachis.

Faurie 240 (K); Kalihi, 500 m, Oct. 1909, *Faurie 244* (P); Kalihi, 500 m, Oct. 1909, *Faurie 243* (US, P); Kalihi, 900 m, Oct. 1909, *Faurie 42* (P); Palolo crater, Under rather heavy foliage 1t 1800 ft., on Kaau or Palolo crater ridge, 2 May, 1920, *D. Wesley Garber 402* (US); Mt. Kaala, 2000-4000 ft, 9 Jul., 1916, *A. S. Hitchcock 14006* (US); Honolulu, Kalihi valley, 2 Aug., 1916, *A. S. Hitchcock 14092* (US); Bowman trail ridge, about 2000 m, 20 May, 1923, *Topping 2643* (NY); Between Puu Kanehoa and Puu Hapapa, 20 Jul. 1924, *Topping 2802* (NY); Puu Kaua, 22 Jun., 1924, *Topping 2793* (NY); Mt Olympus, wooded ridge at 1700 ft, 9 Jan. 1927, *Otto Degener 3619* (NY, US); Hauula, in wet forest, 3 Nov. 1927, *Otto Degener 5794* (NY, US); base of cliff to right of Nuunu Pali, 20 Jan. 1929, *Otto Degener & Hamilton Rodrigues 3633* (K, NY); along Pupukea Hakuku trail, 1 April 1929, *Otto Degener, Henry Kaipo & A. C. Tong 3613* (NY); Puu Peahinaia, thick wood, alt. 1500 ft, 28 Apr. 1929, *Topping 3323* (NY); Waiahole Waikane trail, old tree trunk, 8 Feb. 1931, *Topping 3414* (NY); Kanehoa, park, 5 Jul.1931, *O. Degener 10455 1b* (NY); Kanehoa, Oahu, in rain forest, 5 Jul. 1931, *Otto Degener & K. K. Park 5795(3a)* (US); Moist woods, head of valley, Puu Hapapa, Waianae Mountains, Honouliuli, 2400 ft, 25 Oct. 1931, *H. St. John 11130* (L, US); Pupukea Kahuku region 5 Mar., 1932, *Otto Degener, K. K. Park & Y. Nitta 5798* (NY); Fire break trail, shady bank, 13 Mar., 1932, *Topping 3495* (NY, US). Waianae Ridge, shady ridge, 24 Apr., 1932, *Topping 3517* (NY); Middle ridge of Niu valley, 4 Jun., 1932, *Otto Degener, K. K. Park & Y. Nitta 5800* (NY, US); Piko trail, Makua, 17 Jul., 1932, *Topping 3576* (NY); Wooded ridge, east of gulch, Kaupakuhale, Mokuleia, Puu Kaala, Waianae Mountains, 23 Oct., 1932, *F. R. Fosberg & H. St. Johns 8919* (NY, US); Moist forest in gulch on NE slope of Puu Hapapa, Waianae range, 30 Oct., 1932, *T. G. Yunker 3350* (NY); Small valley SE of Puu Hapapa, 30 Oct., 1932, *Otto Degener, Parls, T. Yamamoto and Y. Iwatsuki 9189* (NY); NE slope of Puu Hapapa, Waianae range, 6 Nov., 1932, *T. G. Yunker 3351* (NY, US); Kaleuao Waimako Ridge, Koolau Mountains, moist forest, steep bluff, 510 m, 30 Apr., 1933, *F.*

Figure 6. Distribution of the species throughout Malesia and Polynesia.

R. Fosberg 9444 (US); Anahulu Trail, Koolau Range, 16 Jun., 1935, *Otto Degener, Park, Bush, Patter & Topping 9924* (NY); Kuliouou valley 23 Jun., 1935, *Otto Degener, K. Park & D. Topping 9926* (NY, US); East Ridge of Kaipapau valley 25 Jul., 1935, *Otto Degener & Kwan Kee Park 9925* (NY); Palehua, Wainae Range, wet underbrush at summit, 23 Nov., 1935, *Otto Degener, K. Park & M. Takamoto 10164* (US); SE slope of Kaala, 19 Dec., 1937, *Otto Degener, Salucop & Arlantico 11574* (L, NY, US); Growing on leeward slopes of Puu Kalena, 1 Oct., 1944, *Neal Gilbert 324* (US); Mount Kaala, Waianae Range, 17 Nov. , 1946, *Islawan 330* (NY); Ridge trail to Palikea, Waianae Ridge, 2 Jul., 1947, *Richard Cowan 651* (NY); Second ridge east of Dupont Trail, Kaala, 24 July, 1949, *O. Degener 21024* (BM); Mokuleia, Waianae Mountains, 2000 ft, 28 Feb. 1954, *C. H. Lamoureux 95* (L); wet woods, Waikele gulch, Waianae Range, alt. 2000 ft, Dec. 1960, *T. M. C. Taylor 6378* (US); Between Mauna Kapu and Palikea, Waianae Mountains, 860 m, 2 Dec, 1961, *V. J. Krajina s. n.* (NY); Near road, Mount Kaala, on ground in forest, 21 Nov., 1962, *Otto Degener & Isa Degener 28011* (L, NY, US); Trail from Maunauna to Kolekole Pass, Waianae range, elev. ca 1600 ft, 9 Jul., 1964, *M. R. Crosby & W. R. Anderson 1709* (US); Waianae trail, beneath a dense exotic canopy, common at this locale, 11 Dec. 1983, *W. Takeuchi, R. Yee, W. Wagner & J. Obata Waianae-10b* (P); terrestrial fern, young leaves covered in reddish brown hairs, common, Waianae Kai, Kamaileunu, 800 m, 14 Sep. 1992, *M. M. J. van Balgooy 6164* (L). **Kauai:** Kaholuamanoa above Waimea, 1-8 Oct., 1895, *A. A. Heller 2853* (NY, US); Hanapepe and Wahiawa watershed, 18 July, 1895, *A. A. Heller 2588* (isotypes of *A. glabratum*, BM, K, P, US); Without specific locality, *G. van Ingen 1898* (NY); Glenwood, 600 m, May 1909, *Faurie 237* (P); Glenwood, May 1909, *Faurie 244* (P); Waimea, 1000 m, Feb. 1910, *Faurie 242* (BM, P); Olokele canyon, 3 Jun., 1926, *Otto Degener & Henry Wiebke 3614* (NY, US); Kilohana crater, 10 June , 1926, *Otto Degener & Henry Wiebke 3660* (NY, US); Halii valley in wet woods, 11 Jun., 1926, *Otto Degener & Henry Wiebke 3620* (NY, US); Hanapepe 19 Jun., 1926, *Otto Degener & Henry Wiebke 3661* (NY, US); Waianae Mts., Honouliuli, moist woods, head of valley, 2400 ft, 25 Oct., 1931, *H. St. John 11130* (K); East of Kumuweia ridge at 3500 ft, 7 Feb., 1950, *Otto Degener 20577* (NY); Hanalai district, Waipa Ahupuaa SW of Waipa stream, 940- -960 ft, 2 Dec., 1988, *Tim Flynn 3224* (US); Kawaihau district, Lihue-Kolea Forest Reserve, Kuilau trail from Keahua Arboretum, elev. 580- -980 ft., 7 Apr., 1989, *Tim Flynn 3309* (US); Kawaihau district, Lihue-Kolea Forest Reserve, Kuilau Trail from Keahua Arboretum, 240 m, 9 Jun., 1990, *W. L. Wagner & T. Flynn 6304* (US); Oahu, *Seeman s. n.* (K); Oahu, *Beechey s. n.* (K); Oahu, *Capt. Beechey s. n.* (K). **Lanai:** West ridge at 2800 ft. 1 Feb., 1964, *Otto Degener and Isa Degener 35 747* (NY). **Maui:** Makawao, 800 m, Aug. 1909, *Faurie 240* (BM, P); Yao Valley, 800 m, Sept. 1909, *Faurie241* (P); Halehaku ridge, June 16, 1920, *C. N. Forbes 2537* (K); Hanaulaiki gulch, west of Papalaua, 12 April, 1995, *K. R. Wood 4230* (NY). **Molokai:** Head of Waihanau stream, 24 May, 1928, *Otto Degener 3617* (NY); At brink of precipice east of Kalaupapa settlement, 19 Jun., 1928, *Otto Degener & Henry Wiebke 3616* (NY, US); Upper part of Halawaiki gulch, in woods, 21 Jun., 1928, *Otto Degener & Henry Wiebke 3615* (NY, US). **Hawaiian Islands**: Insulae sandvicenisis, 1871, *Hillebrand 17457* (BM) Sandwich Islands, without locality, *Lucien Underwood s. n.* (NY); Sandwich Islands without locality, *Hillebrand 14* (K); Sandwich Islands without locality, *Hillebrand 15* (K); Sandwich Islands without locality, *Hinds 1841* (K); Herb. H. Christ, Basil., 1892, Sandwich Islands, without locality, *D. D. Baldwin s. n.* (P); Hawaiian Islands, without locality, *D. D. Baldwin s. n.* (NY); Ex Herb. D. Baldwin, *D. D. Baldwin 45* (NY, US); Hawaiian Islands, about 1890, *May Godbe s.*

n. (US); Hawaiian Islands, ex Herbarium *G. W. Lichtenhaler* s. n. (US); Hawaiian Islands, 1877, *A. B. Lyons s. n.* (US); ex Herb. W. Hillebrand s. n. (BM); Sandwich Islands, *Hildebrand s. n.* (BM). **FIJI: Viti Levu:** Namusi, *Graeffe s. n.* (US). **SAMOA**: **Upolu:** Lac Lanu-to, forêt très dense, epiphyte, 760, m, 23 Mar. 1905, *B. P. G. Hochreutiner 3295* (L); Sane region, 1864 m, 1869, *E. Graeffe 346* (US); Malololelei, ridge, forest, 700 m, 14 Aug., 1929, *E. Christophersen 244* (US); Samoa Insel, Upolu, 16 Jun. 1931, no collector (BM); epiphytic in forest at Afiamalu, 2250 ft, 18 Jan. 1965, *W. A. Sledge 1522* (L); Mt. Tofua, *Dr. Graeffe 1118* (US); Apia, 300-400 m, *Belche s. n.* (P); Apia, 2000 ft, 1980, *Belche s. n.* (P). **Savaii:** Vulkan Maungaufi, epiphyte 1500-1600 m, 1905, *K. u. L. Rechinger 1976* (US); without specific locality in Savaii Is., *Dr. Graeffe s. n.* (US); Marigaloa, 900 m, 3 May 1906, *F. Vaupel 72* (P); Aopo, 700 m, 10 Jul. 1905, *F. Vaupel 72* (US); Mataana, 1600 m, 4 Nov. 1905, *F. Vaupel* 72 (US); Savai, Samoa, *E. Graeffe 242* (BM). **AMERICAN SAMOA: Tau:** ground fern growing in the rainforest near Laufuti on the south side of the island. 400 m, 16 Jul., 1976, *A. Whistler W3590* (US). **NEW ZEALAND TERRITORY: COOK ISLANDS: Rarotonga:** Avana valley, terrestrial fern, 18 Sep., 1969, *W R. Philipson 10469* (L, US); Le Manga, rain forest, terrestrial fern, 14 Sep., 1969, *W.R. Philipson 10386* (L, US); Ikurangi, near top of sharp ridge ca. 1550 ft., in low forest on south side below Blechnum procerum. 28 Jul., 1975. *W. R. Sykes 1966/CI* (US). **FRENCH POLYNESIA: SOCIETY ISLANDS: Tahiti:** Vallée de la Reine, 1 Oct. 1877, *L. Savatier 899* (K, P); Mt. Aorai, several plants on old tree fern stumps under Metrosideros, 1775 m, 12 Sep., 1977, *B. H. Gagne 1586* (US); NW ridge of Pic Vert, above Papéete, headwaters of lower branch of Tipaerui river, rare, terrestrial, in montane rain forest on steep slope, 950-1000 m, 17 Jun., 1982, *F. R. Fosberg 62945* (US); Crête ouest de la Papenoo, sentier de l'Orohena, terrestre à rhizome rampant, 685 m, 3 Aug., 1982, *J. Florence 3650 (*US); crête entre les monts Mao Ereere et Moua Turi, epiphyte, rhizome courtement rampant, 610 m, 30 Oct. 1992, *Florence & Tahuaitu 11629*; Tahiti, *Nadeaud 141* (P) (L). **AUSTRAL ISLANDS: Tubuai:** moist woods along steep east slope of Panée, 5 Jul., 1971, *S. H. Sohmer 6767* (US). **Rapa:** Kaimaru, south ridge of Mt. Perahu, moist woods on steep ridge, 475 m, 13 Jul., 1934, *H. St. John and Jean Maireau 15526* (P, US); East ridge of Perau, 400 m, 11 Mar., 1980, *G. Paulay 265* (US); Kaukauamoo, dense forest on south side of ridge, almost erect plant, 350 m, 18 Jul., 1934, *F. R. Fosberg 11560* (US).

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ANISOPHYLLOUS SPECIES OF *SELAGINELLA* IN WEST AFRICA

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Key Words: *Selaginella*, anisophyllous, taxonomy, conservation, West Africa.

ABSTRACT

The 20 anisophyllous species of the genus *Selaginella* Beauv. found in West Africa are revised on the basis of morphological, vegetative features including epidermal details of the leaves. Details of the cones are given including details of the sporophylls, spores and the distribution of the megaspores and microspores in the cones. A key is given for the identification of the West African species.

INTRODUCTION

Selaginella Beauv is generally regarded as the only living genus of the family Selaginellaceae Milde containing about 700 species world-wide. The fossil genera *Selaginellites* Zeiller, *Mittagia* Lignier, *Porostrobus* Nathorst and *Barsostrobus* Fairon-Demaret are also included in the Selaginellaceae (Thomas & Brack-Hanes, 1984). Spring (1850) presented the major monograph of the genus *Selaginella*, as it is presently known, and suggested there to be two subgenera: *Homoeophyllum* containing taxa with isophyllous leaves and *Heterophyllum* containing taxa with anisophyllous leaves. This was accepted by a number of authors who used sub-genera in different ways. Hieronymus made extensive use of the stelar pattern in his taxonomic decision to agree with Spring in having two subgenera, but other authors have differed in the number of subgeneric groups that they accepted. Braun (1865) believed there to be two but renamed Spring's subgenera as *Homotropae* and *Dichotropae* respectively whereas Rothmaler (1944) divided the genus into three genera: *Selaginella*, *Lycopodioides* Boehmer and *Didiclis* Beauv. Baker (1883, 1887) and Walton and Alston (1938) recognized four subgenera - *Selaginella* (=*Euselaginella*), *Stachygynandrum*, *Homostachys* and *Heterostachys*. The divisions all centered on the fact that some species are homophyllous while others are heterophyllous with further divisions being distinguished mainly on the morphology of their strobili.

Jermy, Jones and Colden (1967), Crabbe and Jermy (1973), Alston et al. (1981) and Tryon and Tryon (1981) returned to the concept of recognizing two subgenera - *Selaginella* and *Stachygynandrum*, retaining the names from Baker's (1883, 1887) classification with the other two subgenera *Homostachys* and *Heterostachys*, recognized by Baker (1883, 1887) and Walton and Alston (1938), absorbed into subgenus *Stachygynandrum*. Jermy (1986) then went further by recognising a single genus *Selaginella* with five subgenera. Thomas (2005) then created another subgenus, *Hexaphyllum*, for Carboniferous species of *Selaginella* that have a third pair of very small leaves on their dorsal surface.

More recently, Zhou and Zhang (2015) have recognized six subgenera and 18 sections within the single genus *Selaginella* based on monophyletic groups found in their

phylogenetic analysis. Weststrand and Korall (2016) recognized seven subgenera, in the single genus *Selaginella,* as they combined data from phylogenetic analysis with morphological ones.

There are over 600 anisophyllous species of *Selaginella* (Tryon &Tryon, 1981; Jermy, 1986). Most publications have been on the New World species (e.g. Alston, 1955, Alston et al., 1981). Publications on the Old World (African) species, e.g. Exell (1944), Tardieu-Blot (1964), Jenny in Schelpe (1970), Bizzari (1975, 1981,1983), Quansah & Thomas (1985), Quansah (1988), Abotsi et al. (2018), have been restricted to specific regions or called attention to new species or information discovered, but none has dealt specifically with anisophyllous species. This present work re-examines the morphological, vegetative and reproductive features of the 20 anisophyllous species of *Selaginella* found in West Africa and gives a key to their identification.

KEY TO THE 20 ANISOPHYLLOUS SPECIES OF *SELAGINELLA* IN WEST AFRICA

Sporophylls monomorphous (uniform) .....Section *Homostachys* (1-5)
Sporophylls dimorphous.....Section *Heterostachys* (6-20)
1a. Strobili tetragonous, not resupinate; ventral sporophylls with no sporophyll-pteryx on the adaxial surface.....2
1b. Strobili bilateral, resupinate; ventral sporophylls with sporophyll-pteryx on the adaxial surface.....6
2a. Stems erect; rhizophores restricted to the very base of plant 3
2b. Stems prostrate or climbing, rhizophores distributed more or less on the whole plant 4
3a. Stems soboliferous, glabrous; lateral and axillary leaves with sclerotic cells forming two broad bands running alongside midvein on lamina, serrate; median leaves aristate (aristae up to same length as lamina); strobili wholly microsporangiate or with the dorsal side wholly megasporangiate and the ventral side wholly microsporangiate. Megaspores with distinct equatorial ring - verrucate.....***Selaginella versicolor***
3b. Stems not soboliferous, pubescent at dorsal side; lateral and axillary leaves with no sclerotic cells on lamina, entire (subentire); median leaves caudate; strobili wholly microsporangiate or with a basal megasporangiate zone and an apical microsporangiate zone, megaspores with no equatorial ring, both proximal and distal surfaces baculate .. ..***Selaginella vogelii***
4a. Stems articulated; rhizophores positioned at the ventral side of stem where branching occurs; median leaves elliptic-lanceolate, serrulate-denticulate, acuminate; ....***Selaginella kraussiana***
4b. Stems not articulated; rhizophores positioned where branching occurs; median leaves not elliptic-lanceolate, not serrulate-denticulate, cuspidate 5
5a. Leaves single-veined, lateral and axillary leaves long ciliate-serrate; median leaves short ciliate-serrate; strobili wholly microsporangiate or with the dorsal side wholly megasporangiate and the ventral side wholly microsporangiate..... .....***Selaginella cathedrifolia***
5b. Leaves three-veined, lateral and axillary leaves serrate; median leaves serrate-serrulate; strobili with a single basal megasporangium, the rest of the cone being microsporangiate.....***Selaginella myosurus***
6a. Stems prostrate or prostrate-ascendent; rhizophores distributed more or less on the

whole plant 7
6b. Stems erect or suberect; rhizophores restricted to the basal 1/4 or basal 1/3 of plant 8
7a. Lateral and axillary leaves ciliate at basal half; median leaves deltate, cuspidate; dorsal sporophylls trullate to deltate, long ciliate-serrate strobili with dorsal side wholly megasporangiate and ventral side containing both mega- and micro-sporangia ....***Selaginella buchholzii***
7b. Lateral and axillary leaves entire at basal half; median leaves obovate, caudate; dorsal sporophylls elliptic-ovate, serrate-subentire, ± keeled; strobili with the dorsal side containing both mega and microsporangia in random pattern and the ventral side wholly microsporangiate or may be predominantly either megaporangiate or microsporangiate .....***Selaginella soyauxii***
8.a. Lateral and axillary leaves long ciliate-serrate.....9
8b. Lateral and axillary leaves not long ciliate-serrate.....10
9a. Axillary leaves amphistomatous; median leaves lanceolate, long ciliate-serrate, cuspidate; strobili with the dorsal side wholly megasporangiate and the ventral side wholly microsporangiate or containing both mega- and micro-sporangia; megaspores loosely reticulate .....***Selaginella blepharophylla***
9b. Axillary leaves hypostomatous; median leaves weakly oblanceolate, ciliate-serrate, aristate; strobili with the dorsal side wholly megasporangiate and the ventral side megasporangiate or containing both mega- and micro-sporangia or wholly megasporangiate; megaspores granulose to minutely rugulose .....***Selaginella zechii***
10.a . Lateral and axillary leaves with sclerotic cells forming patches and bands on lamina; dorsal sporophylls short ciliate-aculeate, cuspidate 11
10b. Lateral and axillary leaves with no sclerotic cells on lamina; dorsal sporophylls not short ciliate-aculeate, not cuspidate 12
11a. Lateral leaves ovate-elliptic, short ciliate-serrate, acuminate; median leaves ovate-lanceolate, aristate strobili with the dorsal side wholly megasporangiate or with meagsporagia and microsporangia and the ventral sporophylls sterile; megaspores finely rugulose-reticulate .....***Selaginella protensa***
11b. Lateral leaves ovate-oblong, serrate-subentire, acute to apiculate; median leaves deltate, cuspidate; strobili with the dorsal side wholly megasporangiate and the ventral side containing both mega- and micro-sporangia or wholly megasporangiate; ventral sporophylls fertile; megaspores compactly reticulate .....***Selaginella tenerrima***
12a. Stems pendent, arching and rooting at tips; lateral and axillary leaves long ciliate-serrate; lateral leaves deltate-ovate; axillary leaves deltate; median leaves long ciliate-serrate; ventral sporophylls with partial sporophyll-pteryx on adaxial surfaces; megaspores verrucate-scabrate.....***Selaginella kalbreyeri***
12b. Stems not pendent, branched at the base; branch systems 3-5 pseudopinnate; rhizophores arising at the axils of the primary branches and restricted to the basal third of the plant; lateral and axillary leaves short ciliate-serrate; lateral leaves sub-entire at basal half, axillary leaves ovate; median leaves distantly serrate, ventral sporophylls with complete sporophyll-pteryx on adaxial surfaces; megaspores loosely reticulate or rugulose 13
13a. Lateral and axillary leaves short ciliate-serrate; dorsal sporophylls cuspidate 14
13b. Lateral and axillary leaves short ciliate; dorsal sporophylls aristate or cuspidate15
14a. Median leaves oblanceolate, aristate ventral sporophylls aculeate-denticulate, apiculate; dorsal sporophylls ciliate; strobili with determinate growth form, wholly

microsporangiate or with the dorsal side containing both mega and microsporangia in random pattern and the ventral side wholly microsporangiate; megaspores reticulate.... .....***Selaginella leoneensis***
14b. Median leaves elliptic-ovate, aristate (aristae up to same length as lamina) ; ventral sporophylls short ciliate-serrate, acute to acuminate; dorsal sporophylls short ciliate; strobili with intermittent and determinate growth forms and with the dorsal side wholly megasporangiate and the ventral side containing both mega- and micro-sporangia; megaspores rugulose .....***Selaginella molleri***
15a. Median leaves ciliate-serrate 16
15b. Median leaves not ciliate-serrate.....17
16a. Lateral leaves elliptic-oblong to ovate-oblong, subobtuse to mucronulate; strobili with the dorsal side wholly megasporangiate and the ventral side wholly microsporangiate or containing both mega- and micro-sporangia or wholly microsporangiate; megaspores reticulate .....***Selaginella molliceps***
16b. Lateral leaves acuminate; strobili with the dorsal side wholly megasporangiate or containing both mega-and microsporangia, ventral sporophylls sterile; megaspores rugulose .....***Selaginella subcordata***
17a. Median leaves long aristate 18
17b. Median leaves short aristate 19
18a. Lateral and axillary leaves entire, acute to mucronulate; aristae of median leaves up to 1.5 times as long as lamina; ventral sporophylls entire; dorsal sporophylls ovate, subentire-serrate; megaspores reticulate-rugulose .....***Selaginella squarrosa***
18b. Lateral and axillary leaves serrate subentire, acute; aristae of median leaves more than 1.5 times the length of lamina; ventral sporophylls aculeate-entire; dorsal sporophylls lanceolate, serrate; megaspores rugulose.... ***Selaginella serrato-squarrosa***
19a. Stems soboliferous; lateral, median and axillary leaves amphistomatous; lateral leaves serrate-denticulate, acute to apiculate; median leaves aristate, subcordate to cordate; dorsal sporophylls ovate-lanceolate, short ciliate to serrate, cuspidate; strobili with the dorsal side having a basal megasporangiate zone and an apical microsporangiate zone but sometimes randomly arranged and the ventral side wholly microsporangiate; megaspores scabrate-verrucate.....***Selaginella goudotiana***
19b. Stems not soboliferous; lateral, median and axillary leaves hypostomatous; lateral leaves serrate, subobtuse to acute; median leaves cuspidate, oblique; dorsal sporophylls subtriangular to weakly deltate, serrate-serrulate, acuminate; strobili with the dorsal side wholly megasporangiate and the ventral side containing both mega- and micro-sporangia or wholly megasporangiate; megaspores reticulate .....***Selaginella thomensis***

TAXONOMIC TREATMENT

There are many vegetative and reproductive characters that can be used to distinguish the species and very rarely does a single character separate one species from the rest. The specimens examined came from the following herbaria: B, BM, K, LG, and from private collections of Dr A. Fay of New York. All cited specimens have been seen by the primary author.

The taxonomic treatment for each species is listed in alphabetical order of species name. The conservation status for the species is based on how frequent they were seen in the field and the number and spread of herbarium specimens. A DD (Data Deficient) status has been given to those species with low distribution (present in six or fewer countries) and a LC (Least Concern) status for those with wide altitude range and a wide

distribution (found in more than six countries).

Selaginella blepharophylla Alston in Mémoires de l'Institute Français d'Afique Noire. 50: 40 t. 6, ff. 9-15 (1957). Type: Liberia: south of Kitoma, clay bank by roadside, 18 Sept. 1949, *F. Harley* 156 (B000685253, holotype).
Figures 1E, 3.
Plants erect or suberect; main stem branched in the lower quarter; branch-systems 3 – 4 pseudopinnate; rhizophores arising at the axils of primary branches. Leaves anisophyllous, single-veined; stomata 28 – 34 x 1826 μm; ligules up to 0.35 mm long, elongate, obclavate. Lateral leaves asymmetrical, ovate-deltate, up to 4.0 x 2.2 mm, base oblique, apex acute, margins of basal half subentire-long ciliate (cilia up to 0.32 mm long), apical half distantly serrate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate sinuous cells, with sclerotic cells forming patches and/or bands on lamina, stomata distributed sparsely on margins but more concentrated on the midvein, Stomatal Index (SI) 21 – 23. Median leaves asymmetrical, broadly lanceolate, up to 2.5 x 1.3 mm, base obtuse, apex cuspidate, margins long-ciliate-serrate (cilia up to 0.36 mm long); ligular surface epidermis with elongate, sinuous cells, without stomata; aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata concentrated along the midvein and/or margins, SI 7 – 9. Axillary leaves symmetrical to sub-symmetrical, ovate, up to 3.8 x 2.4 mm, base obtuse to shortly truncate, apex acute to weakly acuminate, margins of basal half long-ciliate (cilia up to 0.45 mm long), apical half serrate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, with stomata concentrated on margins, SI 11 – 13; aligular surface epidermis with elongate, sinuous cells, with sclerotic cells forming patches and/or bands on lamina, stomata concentrated on midvein and/or occasionally on lamina, SI 18 – 20. Strobili bilateral, resupinate, at the apices of branchlets, up to 10 mm long, with two sporangial arrangements: (a) with dorsal side wholly megasporangiate and the ventral side wholly microsporangiate; (b) with dorsal side wholly megasporangiate and the ventral side containing both megasporangia and microsporangia randomly arranged. Sporophylls dimorphous. Ventral sporophylls ovate-sub-deltate to ovate-oblong, up to 3.6 x 1.7 mm, base oblique (truncate-obtuse), apex broadly acute, margins short-ciliate-serrate (cilia up to 0.16 mm long), with a complete sporophyll-pteryx on the adaxial surface; ligular surface epidermis with elongate, sinuous cells, stomata scattered on lamina, SI 8 – 9, aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata sparsely distributed on lamina and margins, SI 5 – 6; sporophyll-pteryx with ciliate margin (cilia up to 0.18 mm long), with elongate, sinuous to straight-sided cells. Dorsal sporophylls lanceolate to sub-ovate, up to 2.2 x 1.0 mm, base sub-obtuse to oblique, apex cuspidate, margins ciliate (cilia up to 0.24 mm long); ligular surface epidermis with elongate, straight-sided cells, without stomata; aligular surface epidermis with elongate, straight-sided cells on lamina and elongate, sinuous cells on the midvein, stomata sparsely distributed on midvein, SI 9 – 11. Megasporangia ovoid-triangular, with similar-sized spores; megaspores 198 – (M 225) – 240 μm in widest area, trilete, tetrahedral-sub-triangular, both proximal and distal surfaces loosely reticulate. Microsporangia ovoid-ellipsoid; microspores 27 – (M 30) – 35 μm in equatorial diam. trilete, globose, both proximal and distal surfaces finely granulose.
RECOGNITION. This species is distinguished by its long ciliate leaves and from *S. zechii* by its reticulate megaspores.

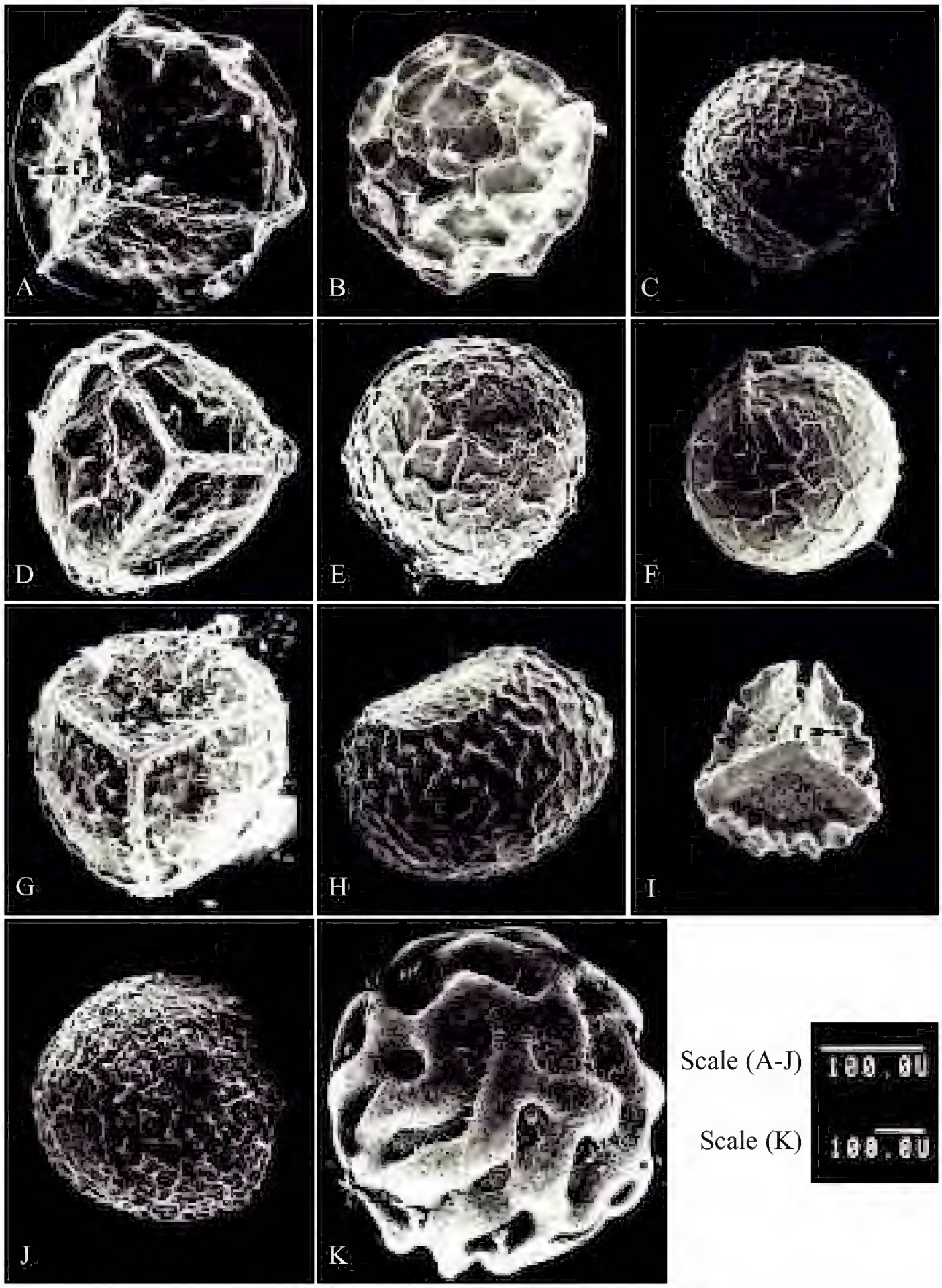

Figure 1. Megaspores. **A, B** *Selaginella versicolor*, **A** proximal surface (r - equatorial flange), **B** distal surface (from Hossain 40003, BM); **C** *S. tenerrima* distal surface (from Welwitsch 451, B); **D** *S. molliceps* proximal surface (from Exell 500, BM); **E** *S. blepharophylla* distal surface (from Harley 156, BM); **F.** *S. leoneensis* lateral view (from Brown and Brown 79, B); **G** *S. serrato-squarrosa* proximal surface (from Nickles 102, B); **H, I** *S. cathedrifolia* **H** side view, **I** proximal surface (r – equatorial flange) (From Guinea 188, BM); **J** *S. thomensis* distal surface (from Exell 423, BM); **K** *S. myosurus* distal surface (from Gossweiler 7029, BM).

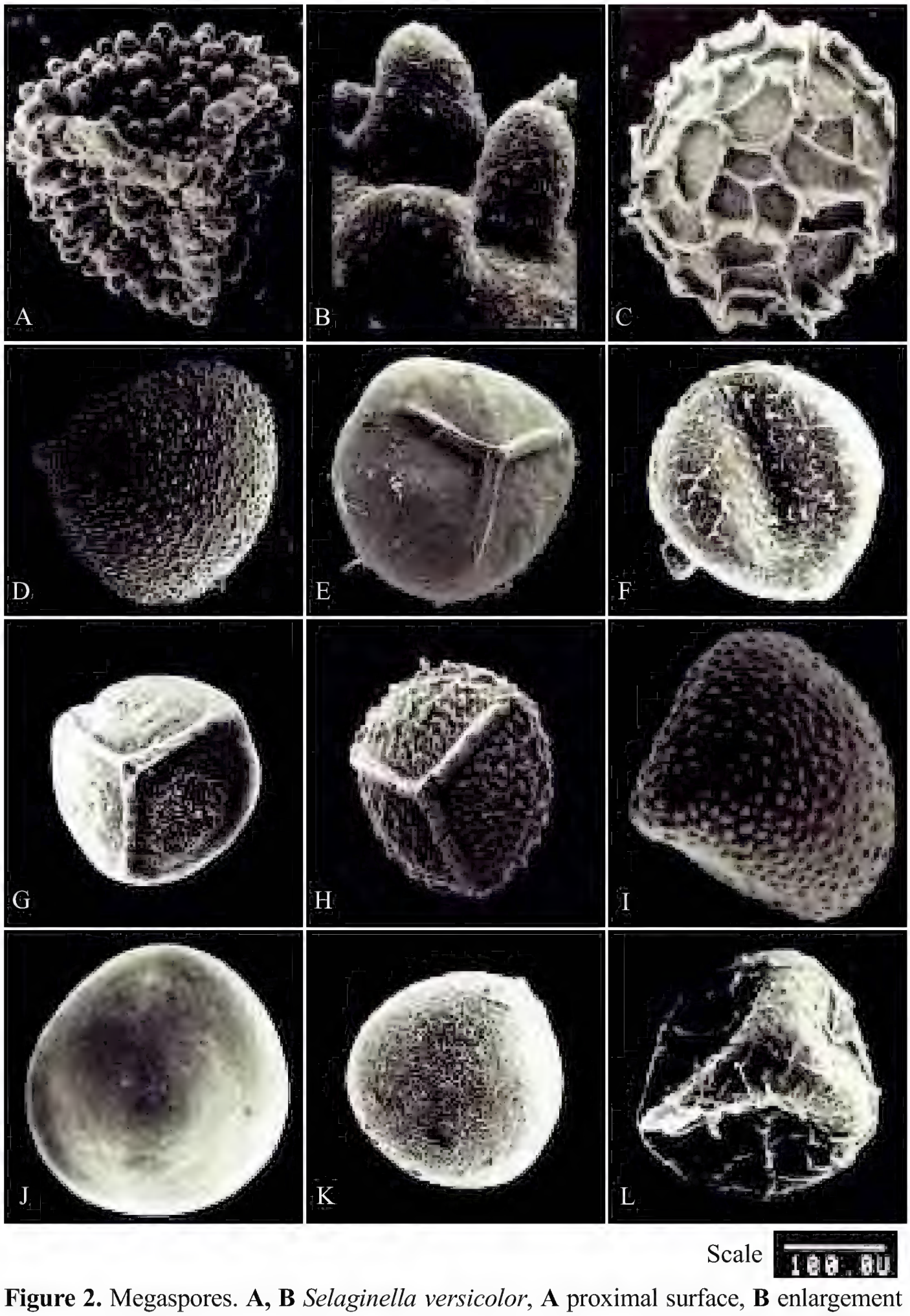

Figure 2. Megaspores. **A, B** *Selaginella versicolor*, **A** proximal surface, **B** enlargement (from Box 3589 BM); **C** *S. kraussiana* distal surface (Rosevear 37 BM); **D** *S. kalbreyeri* distal surface (Abbeyes 341 BM); **E** *S. buchholzii* proximal surface (Buchholz s.n. B); **F** *S. molleri* distal surface (Moller 79 pp BM); **G** *S. zechii* proximal surface (Box 3506 BM); **H**. *S. subcordata* proximal surface (Deighton 3087B BM); I. *S. goudotiana* proximal surface (Quartin-Dillon s.n. LG); **J** *S. soyauxi* distal surface (Soyaux 419 K); **K** S. *protensa* distal surface (Portères s.n. P); **L** *S. squarrosa* proximal surface (Mann 1407 K).

DISTRIBUTION**.** Guinea, Liberia, Ivory Coast, Ghana, Togo, Nigeria, Cameroon.
SPECIMENS EXAMINED. **Liberia**: Kitoma: *Harley* F156 (BM, holotype); Sanniquellie: *Baldwin*, *Jr.* 13132 (BM); Bilimu, *Harley* F196 (BM); Bong-Range: between Waimu and Bagoleta, 32 km N of Kakata, *Wilde* 3862 (K); Mt. Bele road, 500 m, *Adams* 612 (K); Ganta, *Harley* F19 (K); Webo: Diebla, *Baldwin* Jr. 6288 (K); **Ivory Coast**: Tai, 3 ml South, Boughey (14) 856 (K); **Ghana**: Axim**:** Ankobra river**,** Avonle stream, *Cudjoe* 116 (BM); Atewa Mt., 800 m, *Bigger* 2425 (K); Prestea: Ampeam F.R., *Cudjoe* 36 (K); **Nigeria**: Plateau Province, William Camp, *Hall* 627 (K); **Cameroon**: Urwaldgebiet: Johann - Albrechtshohe Station, *Staudt* 452 (K).
HABITAT. On wet rocks near streams and wet roadside clay banks in secondary forest; up to 800 m altitude.
CONSERVATION STATUS: Least Concern (LC). This species is widespread across West Africa with collected specimens from many locations, including recent reported presence in Togo (Abotsi et al., 2018).

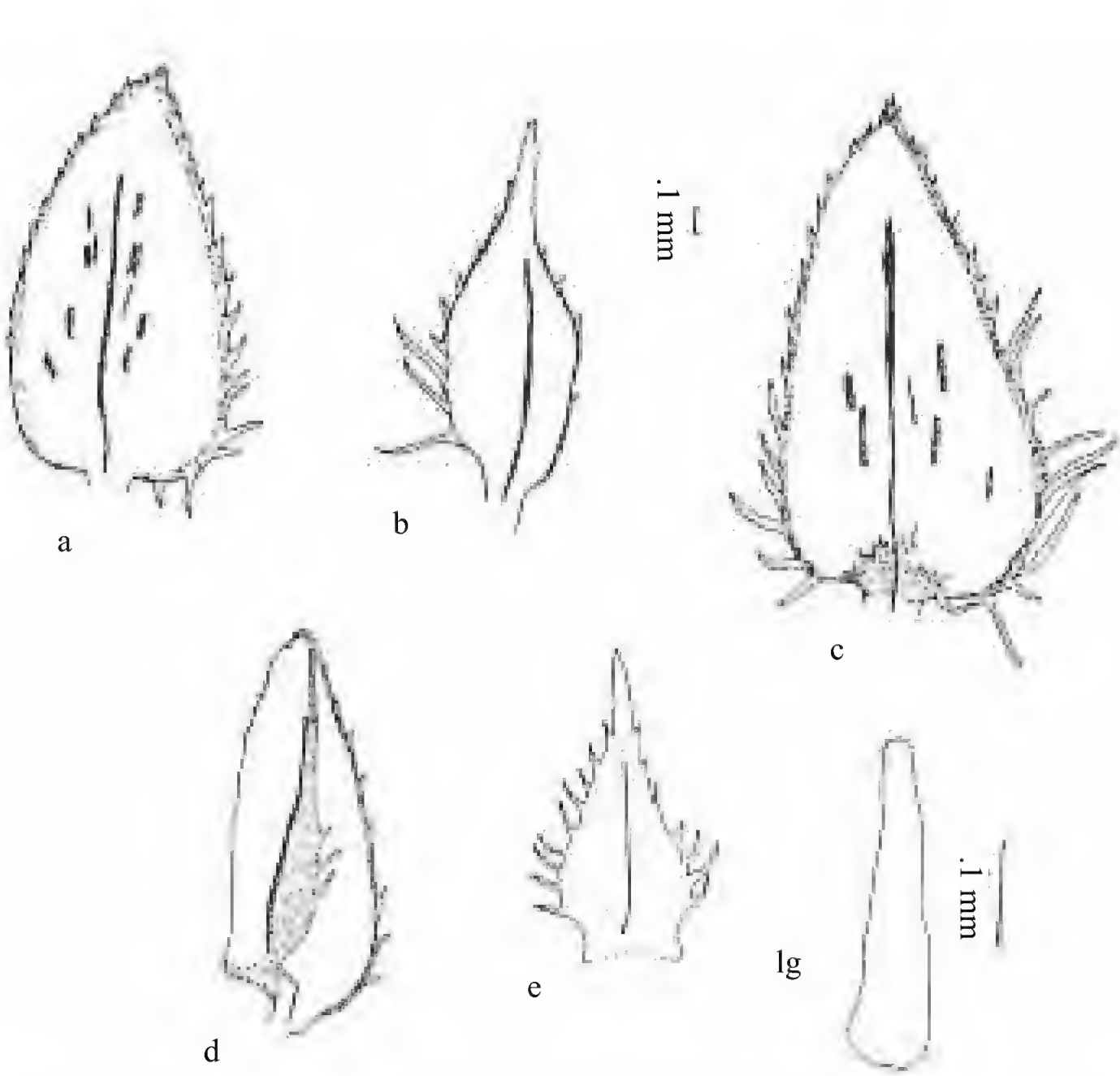

Figure 3. *Selaginella blepharophylla* Alston, a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Harley 156 (BM holotype).

Selaginella buchholzii Hieron in Die natürlichen Pflanzenfamilien, 1, 4: 696 no. 272 (1901). Type: Cameroon: Jansoki, by river Quaqua, *R.W. Buchholz* s.n. (B200077907, holotype; P00466608, P0046609! isotypes).

Figures 2E, 4.

Plants suberect or shortly prostrate, main stem branched at the base; branch-system 1 – 3 pseudopinnate; rhizophores arising at the axils and/or dorsal side of the primary branches and distributed more or less throughout the plant. Leaves anisophyllous, single-veined, with sclerotic cells occasionally present forming patches on lamina at aligular surface epidermis; stomata 19-33 x 18-21 µm; ligules up to 0.23 mm long, obclavate or weakly femurate. Lateral leaves asymmetrical, ovate-oblong to ovate-elliptic, up to 2.3 x 1.3 mm; base obtuse, apex acuminate to weakly mucronate, margins of basal half ciliate-denticulate (cilia up to 0.22 mm long), apical half serrate-serrulate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular

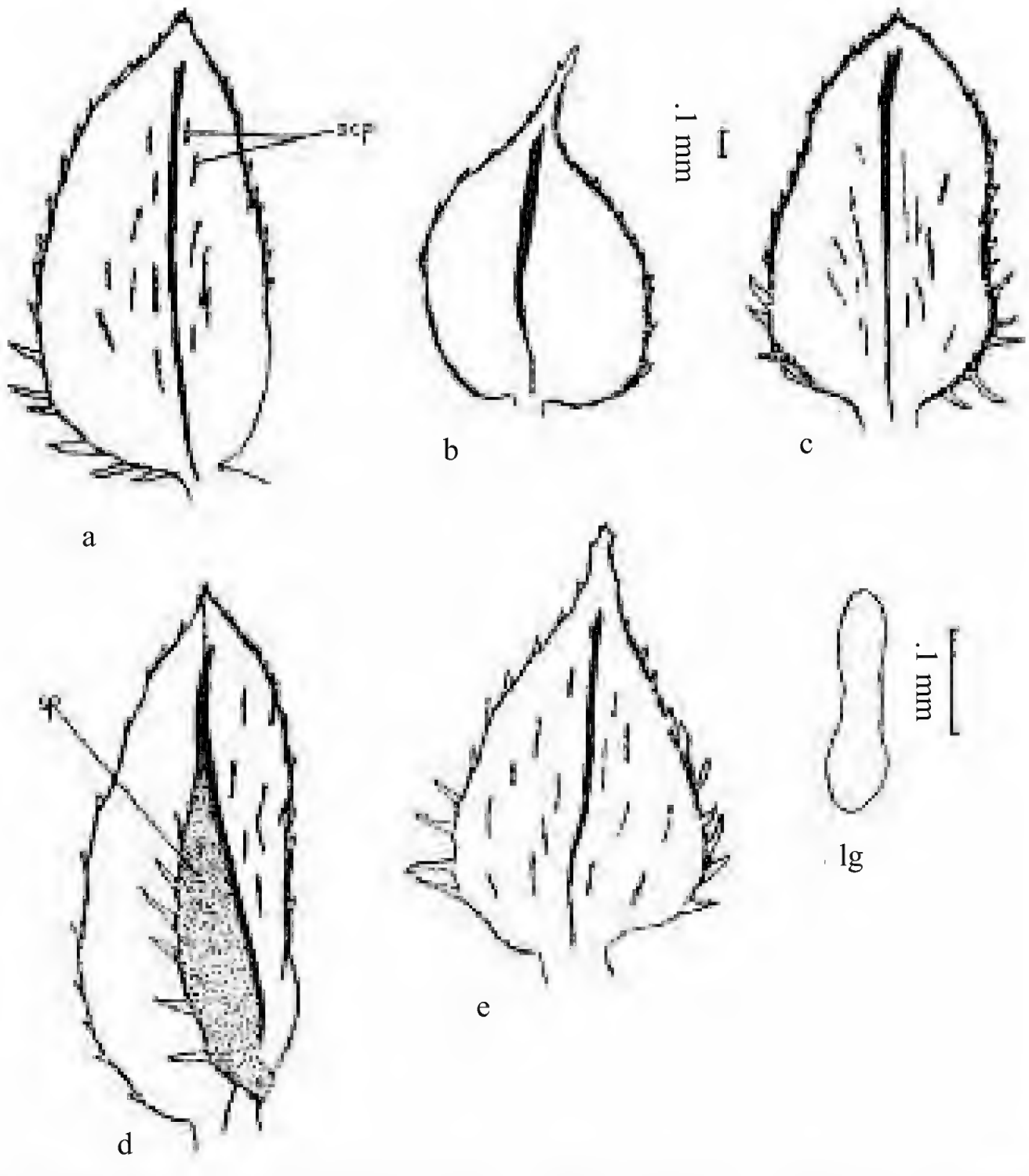

Figure 4. *Selaginella buchholzii* Hieron., a. lateral leaf (spc - sclerotic cells forming patches on lamina), b. median leaf, c. axillary leaf, d. ventral sporophyll (sp - sporophyll-pteryx), e. dorsal sporophyll, lg. ligule. All from Adams 1813 (BM).

surface epidermis with elongate, weakly sinuous to straight-sided cells, stomata evenly distributed on lamina, SI 17 – 20. Median leaves sub-symmetrical, weakly deltate, up to 1.5 x 0.8 mm, base cordate, apex cuspidate, margins serrate-denticulate; ligular surface epidermis with elongate, sinuous cells, without stomata; aligular surface epidermis with isodiametric, polygonal straight-sided cells, stomata sparsely distributed on lamina, SI 8 – 9. Axillary leaves symmetrical, ovate, up to 2.0 x 1.2 mm base obtuse, apex apiculate to acuminate, margins of basal half ciliate (cilia up to 0.22 mm long), apical half serrate-serrulate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, weakly sinuous to straight-sided cells, stomata evenly distributed on lamina, SI 21 – 23. Strobili bilateral, resupinate, at apices of branches, up to 10 mm long, with two sporangial arrangements: (a) cone wholly megasporangiate; (b) with dorsal side wholly megasporangiate and ventral side containing both megasporangia and microsporangia randomly arranged. Sporophylls dimorphous, with sclerotic cells forming patches on lamina at aligular surface epidermis. Ventral sporophylls ovate-sub-panduriform, up to 2.1 x 1.1 mm, base oblique (subcordate-obtuse), apex acuminate, margins aculeate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinuous cells, stomata randomly distributed on lamina at side with sporophyll-pteryx, SI 18 – 20; aligular surface epidermis, with isodiametric, polygonal, straight-sided cells, stomata sparsely distributed on lamina, SI 4 –5; sporophyll-pteryx with ciliate margin (cilia up to 0.23 mm long), with elongate, sinuous cells, stomata (1 – 2) present on the outer side. Dorsal sporophylls trullate to deltate, up to 1.7 x 1.0 mm, base obtuse to subcordate, apex shortly cuspidate to long acuminate, margins long-ciliate-serrate (cilia up to 0.31 mm long); both ligular and aligular surfaces epidermis with elongate, sinuous cells, stomata sparsely distributed on lamina and midvein at aligular surface epidermis only, SI 6 – (M 7) – 7. Megasporangia deltoid, with 91% similar-sized and 9% 3L: 1S spores; megaspores 228 – (M 257) – 300 µm in equatorial diam., trilete, globose, both proximal and distal surfaces finely granulose to psilate. Microsporangia ellipsoid; microspores 20 – (M 24) – 32 µm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces baculate-clavate.

RECOGNITION. This species is closely allied to the Madagascan *S. perpusilla* from which it is distinguished by its ciliate leaves and psilate megaspores.

DISTRIBUTION. Sierra Leone, Ivory Coast, Ghana, Togo, Benin, Nigeria, Cameroon, Gabon, DR Congo.

SPECIMENS EXAMINED. **Sierra Leone**: Musaia: Dembelia, *Small* 271 (BM, K); Loma Mts., *Morton* 2613 (K); Koyema: Tingi Hills, *Morton* & *Gledhill* 3212 (K); Morea Junction to Fintonia, *Morton* & *Gledhill* 580 (K); **Ivory Coast**: Vavoua: Cercle de Daloa, *Abbayes* 167 (BM); **Ghana**: Ankaful: near Cape Coast, *Hall* 2360 (K); Elmina: *Hall* 1522 (K); Accra: Achimota, *Foote* 156 (BM); loc. cit., *Milne-Redhead* 5135 (BM); Ejura Scarp: *Adams* & *Akpabla* 4525 (BM) ; Kpandu: Kpeme, c 250 m, *Adams* 1813 (BM); Anloga: *Hall* 3403 (BM); Nakpanduri: *Hall* CC 511 (BM); Banda: *Hall* 2096 (K); **Togo**: Sokode: *Schroder* s.n. (K); **Nigeria**: Onitsha: Agulu, *Keay* FHL 25288 (BM); Ondo: Orosun, Idanre Hills, *Keay* 25422 (BM); Enugu: *Baldwin, Jr.* 13795 (BM); Ibadan: Oyo Road, *Meikle* 1003 (BM, K); Abeokuta: Olokemeji, *Charter* FHI 31294 (K); **Cameroon**: Jansoki: S.E. Douala, *Buchholz* s.n. (K); **DR Congo**: Mayonibe: Les Bandal, Nickles 118 (BM); Thysville: Vanderyst 4459 (BM); Kisantu: Moyen Congo, Vanderyst 11550 (BM).

HABITAT. Among stones on river banks, under bushes or in dry exposed positions; from

near sea level up to 1000 m.
CONSERVATION STATUS: Least Concern (LC). This species has a very large distribution across West and Central Africa, with many specimens from many locations including recent collections (Abotsi et al., 2018).

Selaginella cathedrifolia Spring in Memoires de l'Académie Belgique 24: 112 (1850).
Syntype: Principe. *Curror* 58 (K000351237, holotype; P00065024, isotype).
Figures 1H , 1I, 5.
S. zenkeri Hieron. ex Bonap., Notes Pteridol. 7: 253 (1911).
Roux, J. P. Synopsis of the Lycophyta and Pteridophyta of Africa, Madagascar and neighbouring islands. *Strelitzia* 23. South African National Biodiversity Institute, Pretoria (2009).
Plants prostrate, branched from the base; branch system 1-3 pseudopinnate; rhizophores arising at the dorsal side and/or the axils of primary branches and distributed more or less throughout the plant. Leaves anisophyllous, single-veined, with sclerotic cells forming patches and/or bands on aligular surface epidermis; stomata 20 – 33 x 15 – 23 µm; ligules up to 0.19 mm long, flabelliform, occasionally bifid or weakly femurate. Lateral leaves asymmetrical, ovate-oblong, up to 2.2 x 1.5 mm, base obtuse, apex acuminate to apiculate, margins long-ciliate-serrate (cilia up to 0.46 mm long) at basal

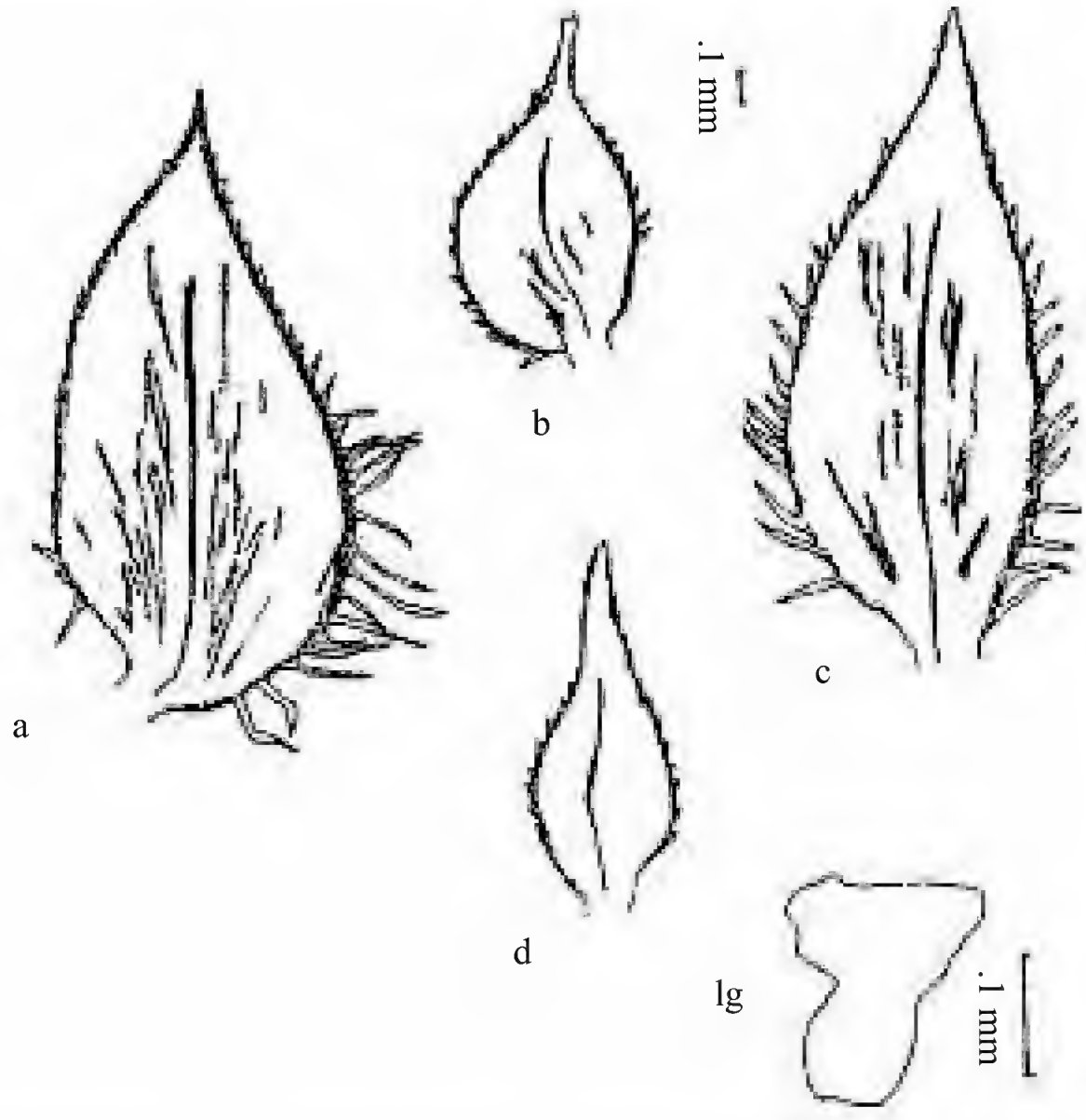

Figure 5. *Selaginella cathedrifolia* Spring, a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, lg. ligule. All from Curror 58 (K, holotype).

half, apical half serrate-denticulate; ligular surface epidermis with isodiametric, sinuous cells on lamina and isodiametric, polygonal, straight-sided cells towards the margins, stomata sparsely distributed near the margins, SI 2 – 3 ; aligular surface epidermis with elongate, straight-sided cells on lamina and less elongate, sinuous cells at the midvein region, stomata concentrated along midvein (not in rows), SI 12 – 14 . Median leaves asymmetrical, ovate, up to 1.1 x 0.6 mm, base obtuse, apex cuspidate, margins short-ciliate-serrate (cilia up to 0.13 mm long); ligular surface epidermis with elongate, sinuous cells, stomata randomly distributed near margins, SI 9 – 10; aligular surface epidermis with isodiametric, sinuous cells, stomata sparsely distributed along midvein, SI 5 – 7. Axillary leaves symmetrical, broadly lanceolate to narrowly ovate, up to 2.2 x 1.6 mm, base obtuse, apex acuminate, margins long-ciliate (cilia up to 0.50 mm long) at basal half, apical half serrate-serrulate; ligular surface epidermis with isodiametric, sinuous cells, stomata occasionally present near margins, SI 4 – 5; aligular surface epidermis with elongate, sinuous cells, stomata concentrated along midvein (not in bands), SI 7 – 8. Strobili tetra- gonous, at apices of branches and/or branchlets, up to 15 mm long, with three sporangial arrangements: (a) with dorsal side wholly megasporangiate and ventral side wholly microsporangiate; (b) with dorsal side containing both msgasporangia and microsporangia randomly arranged and ventral side wholly microsporangiate; and (c) cone wholly microsporangiate. Sporophylls uniform, keeled, ovate-lanceolate, up to 1.2 x 0.5 mm, base obtuse, apex cuspidate, margins serrate-serrulate; both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata sparsely distributed along the midvein, at aligular surface epidermis only, SI 4 – 7. Megasporangia ovoid-triangular, with 81% similar-sized, 14% 2L: 2S and 5 % 3L: 1S spores; megaspores 200 – (M 240) – 298 μm in equatorial diam., with distinct equatorial ring, trilete, sub-globose to globose, proximal surfaces granulose, distal surfaces rugulose. Microsporangia oblong-ellipsoid; microspores 13 – (M 25) – 30 μm in widest area, trilete, tetrahedral-sub-triangular, both proximal and distal surfaces compactly scabrate-echinate.

RECOGNITION. This species is easily distinguished by its long, ciliate, lateral and axillary leaves, combined with the prostrate habit.

DISTRIBUTION. Guinea-Bissau, Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Equatorial Guinea [Rio Muni (RM), FP], Principe, Gabon, Congo, DR Congo, Angola.

SPECIMENS EXAMINED. **Guinea -Bissau**: Mafenebu: Guinea 187 (BM) ; Guinea 188 (BM) ; Guinayong: **Guinea** 100 (BM); Guinea: Ziama: *Schnell* 2664 (BM); Gouee to Nzo: *Abbayes* 619 (BM); Sierra Leone: Bong County: Kpatawee Waterfall, 250 m, *Fay* 1250, 1261 (NY); Kasewe F.R., 250 m, *Fay* 1200, 1278 (NY); Gorama Mende Chiefdom, East Province, 40 m, NNE of Bo, *Fay* 1287 (NY); Njala, bank near river Taia, *Fay* 1058, 1077 (NY); loc. cit., *Deighton* 646 (BM, K); loc. cit., (Kori), Jones 418 (K); Kambi Hills: Waanjee river, *Bakshi* 57 (K); Neaboi, *Small* 892 (K); Between Gorahun and Bobobu, *Deighton* 3649 (K); Kenema, *Deighton* 5224 (K); loc. cit., *Deighton* 5225 (K); Lalehun (Gaura), *Bakshi* 194 (K); Bagroo river, *Mann* 911 (K). **Liberia**: Sanniequellie: Ganta, *Harley* F19 (BM); Kitoma, *Harley* F154 (BM, K); Jaurazon: Sinoe Co., *Baldwin Jr.* 11452 (BM, K); Webo: Mnanulu, *Baldwin Jr.* 6025 (BM, K); loc. cit., Duo, *Baldwin Jr.* 11339 (BM, K); Gbaringa: Pallilah, *Baldwin Jr.* 13129 (BM); loc. cit., NE of Suacoco, *Daniel* 417 (BM); loc. cit., *Barker* 1389 (K); Mt. Bili, *Barker* 71 (K); LAMCO Headquarters Camp, 550 m, *Adams* 479 (K); Between Waimu and Bagoleta, c 32 km N of Kakata, *Wilde* 3871 (K) ; Moala, *Linder* 1378 (K); **Ivory Coast**: Glike, *Schnell* 1631 (BM); Gouee, *Abbayes* 601 (BM); loc.cit., *Abbayes* 2138 (BM); Tai-Tabou,

Hana river bank, *Wilde* 3529 (K); Tai flou Forest near Danane, *Schnell* 6325 (K); **Ghana**: Axim, Ahenlezo, *Cudjoe* 76 (BM); Tarkwa, Ankobra river, *Johnson* 987, 988, 989 (K); Dompim, Neung F. R., *Enti* FE1320 (K); Sekondi, *Fishlock* 21 (K); Nadum, bank of river Offin, *Fishlock* 45 (K); No locality: *Fishlock* s.n. (K); **Nigeria**: Calabar: Gban, *Richards* 5146 (BM); Kwa Falls, c 60 m, *Maggs* 156 (BM, K); loc. cit., *Richards* 3994 (BM, K); Calabar-Mamfe road, *Baldwin Jr.* 1377 (BM); loc. cit., Baldwin Jr. 13764 (BM); Old Calabar, *Thomson* 119 (K); **Cameroon**: Urwaldgebiet: Bipinde, *Zenker* 3095 (BM); loc. cit., *Zenker* 1328 (BM); loc. cit., *Zenker* 102 (BM); loc. cit., *Zenker* 4057 (BM) ; Lolodorf, *Staudt* 24 (BM); loc. cit., *Staudt* 45 (BM); Bertoua, *Nickles* 122 (BM); Munanya road, W. of Mamfe, *Adams* 1335 (BM, K); Lomie, 600 m, *Price & Evans* 64, 196, 229 (K); ALSO SEEN: **Principe**: Pico Papagaio, c 600 m, *Exell* 687 (BM); Infante D. *Henrique*, c 300 m, Exell 629 (BM); Prince Island, *Curror* 58 (K). DR Congo. Luebo-Kasai, *Achten* 367A (BM); Gunbari, Haut Uele, *Seret* 484 (BM).
HABITAT. On rocks and stones on the banks or in stream in wet forests; up to 1500 m.
CONSERVATION STATUS: Least Concern (LC). This species is widespread in its distribution. It occurs across the continent of Africa; from the West through the Centre and the East to the South.

Selaginella goudotiana Spring, Bulletin de l'Académie Bruxelles, 10 (1): 140 (1843). Type: Madagascar: Antananarivo, *Goudot* s.n. (holotype G 362132/1; isotype, B200097414).
Figures 2I, 6.
S. madagascariensis Bak., J. Bot. 18: 372 (1880). Type: Madagascar. Antananarivo, 3/77, *Gilpin* s.n. (lectotype, K);
S. melleri Bak. J. Bot. 18: 372 (1880) Type: Madagascar: Mbatomanga, Aug. 6., 1892, *Meller* s.n. (lectotype, K).
S. magnusii Hieron. in Engler & Prantl, Nat. Pflanzenfam. 1, 4: 686 (1901). Type: Madagascar: Est-Imerina: Urwld von Andragoloaka, Nov.1880, *Hildebrandt* 3782 (lectotype, B; Type numbers in BM, K);
S. abyssinica Spring in Mem. Acad. Belg. 24: 99 (1850); Baker F. Allies 84: no 194 (1887); Knox, Trans. Bot. Soc. Edinb. 35: 263 (1950); Alston, Mem. I.F.A.N. 50: 37-38 (1957), F. & F. Allies W. Trop. Afr. 2nd Ed (Suppl.): 14-17 (1959), Type: Ethiopia: Abyssinia, Sholoda, Quartin-Dillon 9 (lectotype P); *S.* preusii Hieron. in E. & P. Pflanzenfam. 1, 4: 686 no 16 (1901) Type: Cameroon. Buea, *Preuss* s.n. (isotype, K; lectotype, B; Preuss 978).
S. goetzei Hieron. in Engler Bot. Jahrb. Syst. 30: 265 (1901) Type: Cameroon: Ukinga-Berge: Kingika-Berg. Schattigen Sedriss, 2600 m, 25 Mai 1899, *Goetze* 941 (holotype B; isotype, K); *S. whytei* Hieron. in E. and P. Pflanzenfam. 1, 4: 697 (1901) Type: N. Nyasaland [Malawi] *Whyte* s.n. (holotype, B; isotype, K).
S. bueensis Hieron. Hedwigia 43: 20 (1904) Type: Cameroon: Buea, *Preuss* 1079 (holotype, B; isotype, K).
Plants erect to ascending (occasionally trailing), soboliferous, branching from the base, branch-system 2 - 4 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal third of the plant. Leaves anisophyllous, single-veined; stomata 22 – 31 x 18 – 24 μm; ligules up to 0.23 mm long, obclavate. Lateral leaves asymmetrical, narrowly ovate to oblong (ovate-oblong), up to 3.0 x 2.0 mm, base oblique (obtuse-subcuneate), apex acute to apiculate, margins serrate-denticulate; ligular surface epidermis with isodiametric, sinuous cells, stomata randomly distributed at and/or near

the margins, SI 16 – 17; aligular surface epidermis with elongate, sinuous cells, occasionally with sclerotic cells forming bands and patches on lamina, stomata concentrated along the midvein in 2 – 5 rows, SI 19 – 21. Median leaves asymmetrical, lanceolate to narrowly sub-deltate, up to 1.7 x 1.0 mm, base subcordate to weakly cordate, apex aristate (aristae up to half the length of lamina), margins serrate; ligular surface epidermis with elongate, sinuous to straight-sided cells, stomata sparsely distributed at the margins, SI 4 – 5; aligular surface epidermis with isodiametric, sinuous cells, stomata sparsely distributed along the midvein in a single row, SI 5 – 6. Axillary leaves symmetrical, elliptic to narrowly ovate, up to 2.8 x 2.1 mm, base weakly obtuse to cuneate, apex acute to apiculate, margins short ciliate-serrate-denticulate (cilia up to 0.15 mm long); ligular surface epidermis with isodiametric, sinuous cells, stomata randomly distributed at and/or near the margins, SI 13 – 14; aligular surface epidermis with elongate, sinuous cells, occasionally with sclerotic cells forming bands and patches on

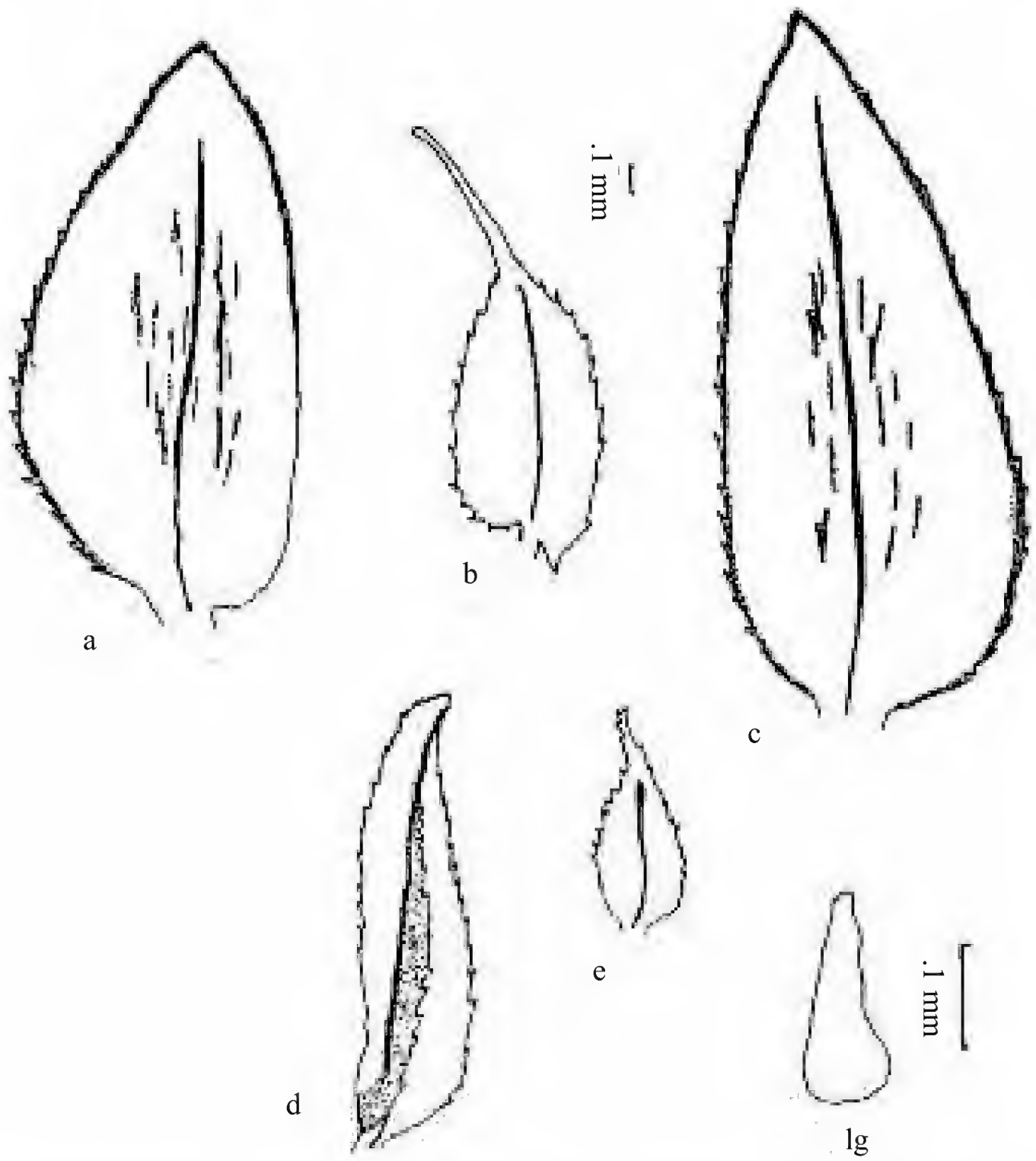

Figure 6. *Selaginella goudotiana* Spring, a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Goudet s.n. (G, holotype,).

lamina, stomata concentrated along the midvein in 2 – 5 rows, SI 18 – 20 . Strobili bilateral, resupinate, at apices of branchlets, up to 4.5 mm long, with two sporangial arrangements: (a) cone with the dorsal side having a basal megasporangiate zone and an apical microsporangiate zone and the ventral side wholly microsporangiate; (b) with the dorsal side containing both megasporangia and microsporangia randomly arranged and the ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls elliptic-lanceolate (-subpanduriform), up to 2.0 x 1.0 mm, base obtuse, apex acute to apiculate, margins aculeate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinuous cells, stomata sparsely distributed on the lamina, SI 5 – 7; aligular surface epidermis with isodiametric, straight-sided cells, stomata sparsely distributed on lamina, SI 3 – 4; sporophyll-pteryx with serrate-serrulate margin, with elongate, sinuous cells, without stomata. Dorsal sporophylls ovate-lanceolate, up to 1.1 x 0.8 mm, base obtuse to broadly cuneate, apex cuspidate, margins short ciliate-serrate (cilia up to 0.16 mm long); both ligular and aligular surfaces epidermis with elongate, sinuous to straight-sided cells, stomata randomly distributed on the lamina at the aligular surface epidermis only, SI 7 – 9. Megasporangia deltoid, with 80% similar-sized and 20% 2L: 2S spores; megaspores 225 – (M 260) – 305 μm in widest area, trilete, subglobose to tetrahedral-subtriangular, both proximal and distal surfaces compactly scabrate-verrucate. Microsporangia ellipsoid to roundish; microspores 25 – (M 35) – 40 μm in equatorial diam., trilete, subglobose, both proximal and distal surfaces verrucate-echinate.

RECOGNITION. This species is distinguished from all other West African species with dimorphic sporophylls by its soboles.

DISTRIBUTION. Ghana, Benin, Nigeria, Cameroon, Equatorial Guinea (Rio Muni, Bioko), Congo, DR Congo, Angola, Rep. S. Africa, Mozambique, Zimbabwe, Zambia, Tanzania, Kenya, Burundi, Uganda, Somalia, Ethiopia, South Sudan.

SPECIMENS EXAMINED. **Nigeria**: Bamenda: Bafut, Bafut-Wum Road, c 900m, *Savory* UCI 308 (BM); Ondo: Akure, Idanre, Orosun Peak, 850 m, *Richards* 3785a (K).; **Cameroon**: Buea: *Preuss* s.n. (Type of *S. preusii* Hieron., K) , loc. cit., *Preuss* s.n. (isotype of *S. bueensis* Hieron., K); Cameroon: Mt.: Road to VHF Radio Station, 2000 m, *Tryon & Tryon* 6519 (K); Deulash, Kingika-Berge, *Goetze* 941 (isotype of *S. goetzei* Hieron., K). **Equatorial Guinea**: Bioko: Moka, Mioko heights, c 2000m, *Adams* 1104 (BM, K); loc. cit., Basakato, c1000m, *Adams* 1006 (BM); loc. cit., Ilache waterfall, c 1200m, Adams 1067 (BM); loc. cit., Peak of Clarence, Mann 667 (K); loc. cit., Heathland' near Biao, *Wrigley &. Melville* 469 (K).

HABITAT. In evergreen forest on wet rocks near streams and waterfalls, as well as open well grazed pasture of higher ground, from 700 m to 2600 m.

CONSERVATION STATUS: Least Concern (LC). The presence of this species in diverse habitats - on wet rocks near streams and waterfalls in evergreen forests; open well-grazed pasture of higher ground, from 700 m to 2600 m as well as coffee/cocoa based agroforestry, added to the fact that it is found widely distributed across the continent of Africa, from West through Centre to East and South, with many specimens collected from diverse locations, confers on this species a non-threatened status, hence LC.

Selaginella kalbreyeri Baker in Journal of Botany, British and Foreign 1884; 276, 277. Type: 'Cameroon mountains, 800 m.: Likombe: 2 April, 1877, *W. Kalbreyer* 164 (K000351235, holotype; B200130239, B200130240, B200130241 isotypes).

Figures 2D, 7.

Plants erect, arching, pendent; branch-system 2 – 4 pseudopinnate and/or flabellate; rhizophores arising at the axils of primary branches and restricted to the basal quarter of plant or at tips of prolonged and pendent branches. Leaves anisophyllous, single-veined; stomata 20 – 31 x 13 – 19 µm; ligules up to 0.24 mm long, pedate, occasionally bifid. Lateral leaves asymmetrical, deltate-ovate, up to 3.5 x 1.5 mm, base oblique (subcordate-truncate), apex broadly acute to sub-obtuse, margins of basal half long-ciliate-serrate (cilia up to 0.45 mm long), apical half serrate-serrulate; ligular surface epidermis with isodiametric, sinuous to straight-sided, cells, without stomata; aligular surface epidermis with elongate, straight-sided cells on lamina and less elongate, weakly sinuous cells at the midvein region, with sclerotic cells occasionally present on lamina, stomata concentrated along midvein in 2 – 4 rows, SI 18 – 19. Median leaves asymmetrical, broadly deltate-ovate to subreniform, up to 1.7 x 1.3 mm, base cordate to weakly auriculate, apex caudate to aristate (aristae up to same length as lamina), margins long-ciliate-serrate (cilia up to 0.56 mm long); ligular surface epidermis with elongate, straight-sided cells, without stomata; aligular surface epidermis with isodiametric, sinuous cells, stomata evenly distributed on lamina, SI 12 – 14. Axillary leaves

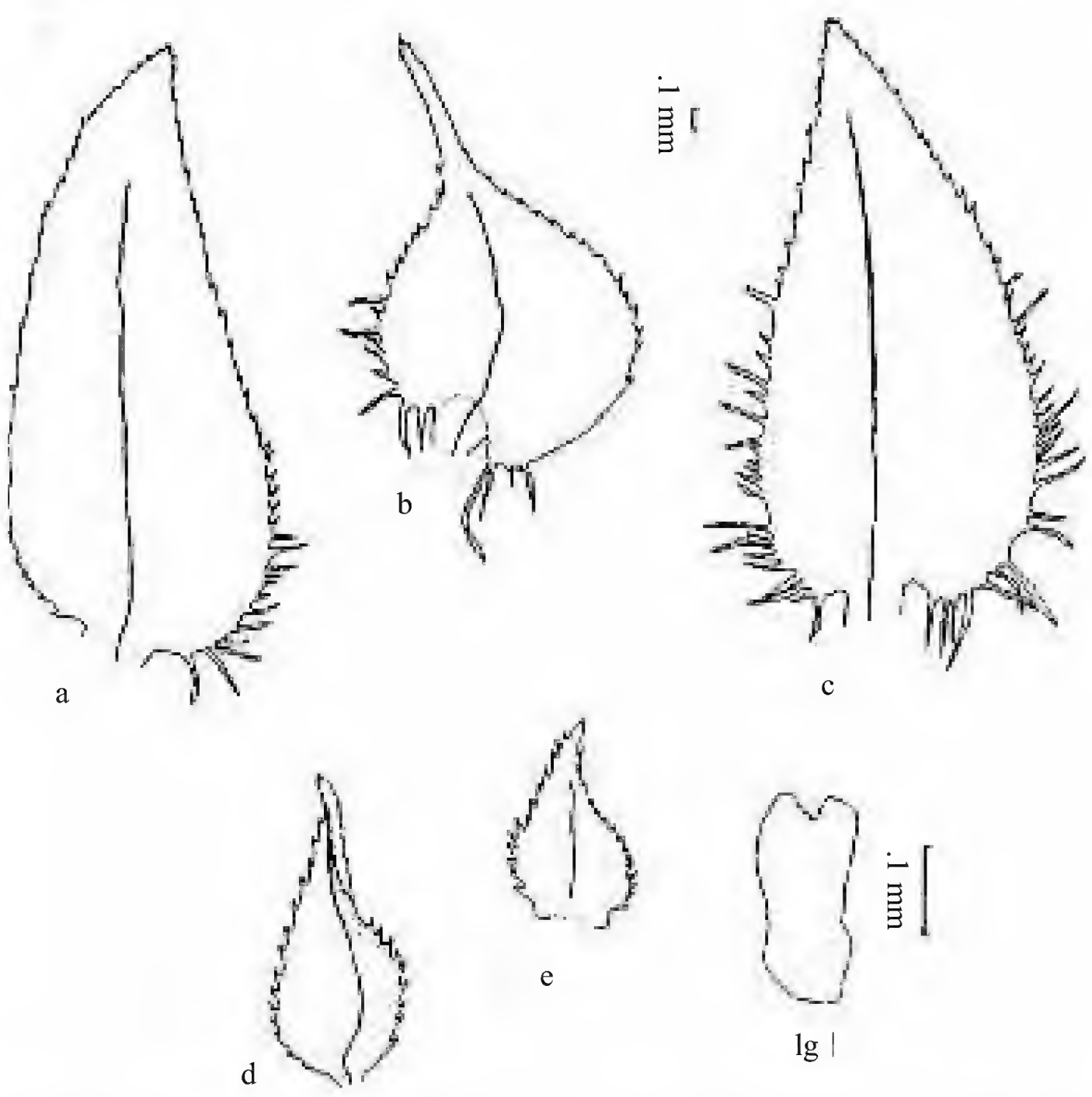

Figure 7. *Selaginella kalbreyeri* Baker, a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Abbayes 341 (BM).

symmetrical, deltate, up to 3.3 x 1.5 mm, base cordate, apex acute, margins long-ciliate-serrate (cilia up to 0.40 mm long); ligular surface epidermis with isodiametric, sinuous to straight-sided cells, without stomata; aligular surface epidermis with elongate, straight-sided cells on lamina and less elongate, weakly sinuous cells at the midvein region, stomata concentrated along the midvein in 2 – 5 rows, SI 19 – 21. Strobili bilateral, resupinate, at apices of branchlets, up to 4.5 mm long, with one sporangial arrangement: with dorsal side containing a basal megasporangiate zone and an apical microsporangiate zone and the ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls ovate-lanceolate, up to 1.8 x 0.9 mm, base obtuse, apex acuminate, margins aculeate-serrate, with a partial sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, slightly sinuous cells, stomata sparsely distributed on lamina and midvein, SI 5 –7; aligular surface epidermis with isodiametric, sinuous to straight-sided cells, stomata sparsely distributed on lamina, SI 2– 3; sporophyll-pteryx with serrate (aculeate) margin, with elongate, slightly sinuous cells, stomata (1 – 3) present on the outer side. Dorsal sporophylls ovate, up to 1.1 x 0.6 mm, base obtuse to sub-truncate, apex cuspidate, margins serrate-serrulate; both ligular and aligular surfaces epidermis with elongate, sinuous to straight-sided cells, stomata sparsely distributed along the midvein at aligular surface epidermis, SI 1 – 2. Megasporangia ovoid-triangular, with similar-sized spores; megaspores 190 – (M 230) – 280 µm in equatorial diam., trilete, globose, both proximal and distal surfaces scabrate-verrucate. Microsporangia broadly oblong to ovoid; microspores 20 – (M 24) – 32 µm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces verrucate.

RECOGNITION. This species is distinguished by its pendent, arching stems, long ciliate leaf margins, and the partial sporophyll-pteryx.

DISTRIBUTION. Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Equatorial Guinea (Bioko), Gabon, Congo, DR Congo, Uganda, Ethiopia.

SPECIMENS EXAMINED. **Guinea**: Dubreka: Mt. Kakoulima, 950 m, *Abbayes* 341 (BM); Wassif, *Schnell* 6672 (BM); **Sierra Leone**: Loma Mt., *Jaeger* 234, 184 (K); loc. cit., Dsrikali, *Jaeger* 952 (K); loc. cit., above Yifin, *Morton & Gledhill* 1131 (K); loc. cit., *Morton* 2765 (K); **Liberia**: Sanniquellie, Bahn, *Harley* F123 (BM); loc. cit., *Baldwin Jr.* 13133 (BM); Nimba Mt. near LAMCO, 1000 m, *Leeuwenberg & Voorhoeve* 4782 (K); **Ivory Coast**: Man: Mt. Tonkoui, 1100 m, *Abbayes* 570 (BM); loc. cit., *Abbayes* 573 (BM); loc. cit., *Cremers* 40302 (K); Beoumi: Seguela, *Abbayes* 517 (BM); **Ghana**: Adaklu, c 400 m, *Hall & Seku* GC 37012 (BM); loc. cit., 600 m, *Hall* GC43386 (K); Lake Bosomtwe, *Irvine* 5127 (K); **Nigeria**: Ondo: Akure, Idanre, *Jones* 3806 (BM); **Cameroon**: Likombe, c 800m, *Kalbreyer* 164 (BM); Buea Forestry Plantation, *Tryon & Tryon* 6483 (K); **Equatorial Guinea**: Bioko: Rio Iladyi, 1180-1190 m, *Benl & Benl* 172 (K).

HABITAT. On wet rocks and banks of water-courses in more or less shaded districts in montane woodlands; up to 1450 m.

CONSERVATION STATUS: Least Concern (LC). This species is widely distributed across the continent of Africa, from West through Centre to the East, with many specimens collected from many different locations, including very recent collections (Abotsi et al., 2018).

Selaginella kraussiana (Kunze) A.Braun, Appendix plantarum novarum in Horo. regio botanico coluntur 1857: 22, 23 (1857). Type: South Africa. Zitzikamma District, *Guinzius* s.n. (K000351291 lectotype).

Figures 2C, 8.

Plants prostrate, branched from the base, stems articulate; branch system flabellate and/or 2 - 4 pseudopinnate; rhizophores arising at the ventral side of primary branches and distributed more or less throughout the plant. Leaves anisophyllous, single-veined; stomata 23 – 31 x 16 – 23 µm, ligules up to 0.35 mm long, femurate. Lateral leaves asymmetrical, ovate-elliptic, up to 4.0 x 1.8 mm , base obtuse, apex acute, margins serrate-serrulate; ligular surface epidermis with elongate, undulating, weakly sinuous to straight-sided cells, without stomata; aligular surface epidermis with elongate, undulating, sinuous cells at the midvein region and elongate, straight-sided cells towards the margins, stomata sparsely distributed on the margins and the apex and concentrated along the midvein in 3 – 5 rows, SI 18 – 21. Median leaves asymmetrical, broadly elliptic-lanceolate, up to 2.8 x 1.0 mm, base oblique, apex acuminate, margins serrulate-denticulate; ligular surface epidermis with elongate, undulating, weakly sinuous to straight-sided cells, without stomata; aligular surface epidermis with undulating,

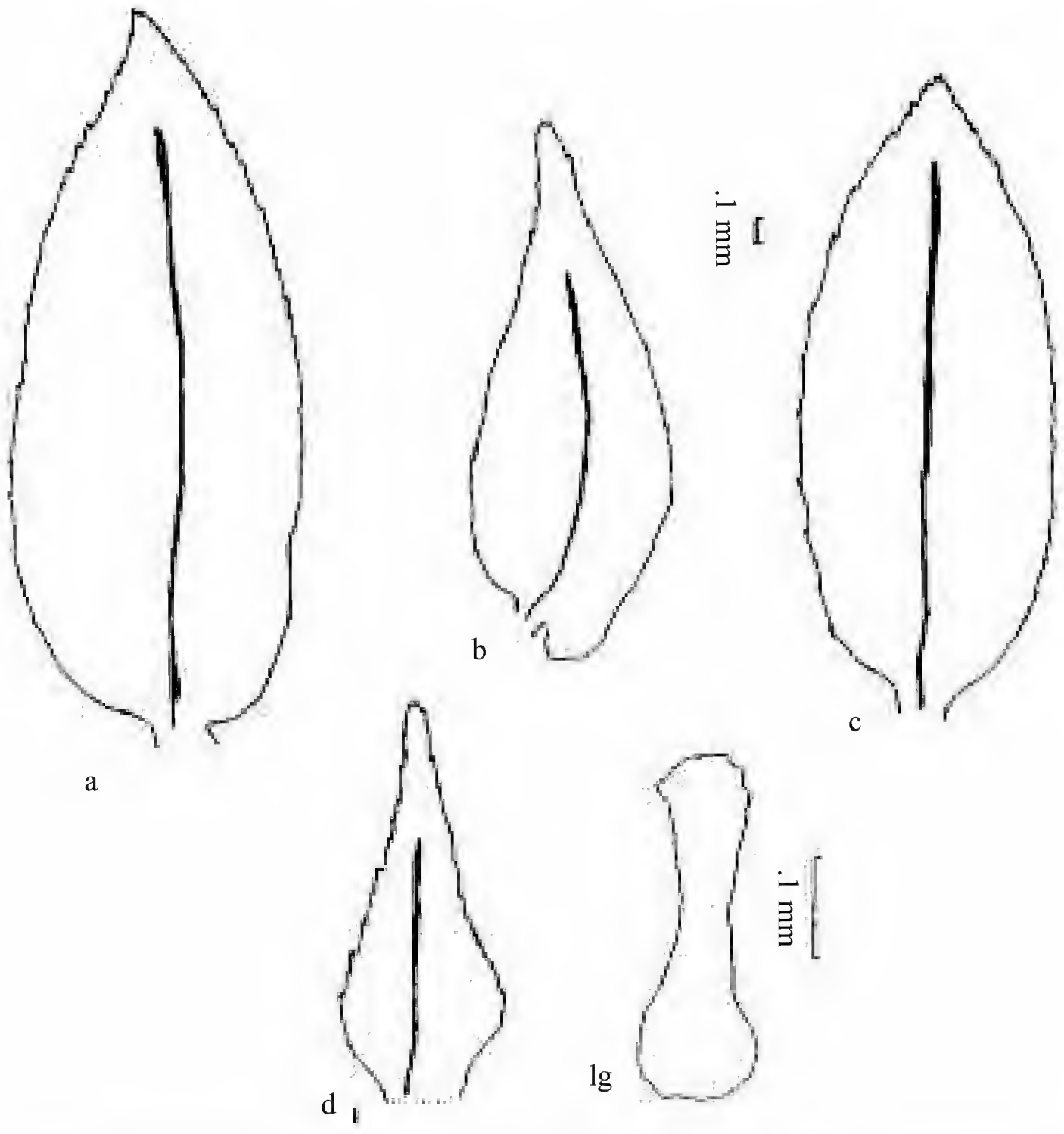

Figure 8. *Selaginella kraussiana* (Kunze) A. Braun, a. lateral leaf, b. median leaf, c. axillary leaf, d. sporophyll, lg. ligule. All from Brenan 4385 (BM).

sinuous cells at the midvein region and elongate, straight-sided cells towards the margins, stomata sparsely distributed on the margins and the apex and concentrated along the midvein in 2 – 4 rows, SI 13 – 15. Axillary leaves symmetrical, oblong-elliptic, up to 3.8 x 2.0 mm, base obtuse, apex acute, margins serrate-serrulate; ligular surface epidermis with elongate, undulating, weakly sinuous to straight-sided cells, without stomata; aligular surface epidermis with elongate, undulating, sinuous cells at the midvein region and elongate, straight-sided cells towards the margins, stomata sparsely distributed on the margins and the apex and concentrated along the midvein in 3 - 6 rows, SI 20 – 23. Strobili tetragonous, at apices of branches and/or branchlets, up to 4 mm long, with one sporangial arrangement: with a single megasporangium at the base, rest of cone being microsporangiate. Sporophylls uniform (sub-uniform), lanceolate-sub-trullate, up to 2.7 x 0.8 mm, base cuneate, apex acuminate, margins serrate-serrulate-denticulate; both ligular and aligular surfaces epidermis with elongate, undulating, weakly sinuous cells, stomata concentrated along the midvein in 1-3 rows, at the aligular surface only, SI 14 – 17. Megasporangia triangular-ovoid to obovoid, with 30% similar-sized, 45% 2L: 2S, and 25% 1L: 3S spores; megaspores 400 – (M 800) – 1100 µm in equatorial diam., occasionally with distinct equatorial ring, trilete, globose, both proximal and distal surfaces cristate-reticulate. Microsporangia oblong to ellipsoid, with annuloid-like cells at the inner basal central surface; microspores 25 – (M 32) – 36 µm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces echinate.

RECOGNITION. *Selaginella kraussiana* is distinguished from all the other West African species by its articulated stems, ventral-positioned rhizophores, and the annuloid-like cells of the microsporangia.

DISTRIBUTION. Sierra Leone, Cameroon, Equatorial Guinea (Bioko), Congo, DR Congo, Rep. S. Africa, Mozambique, Zimbabwe, Malawi, Tanzania, Kenya, Rwanda, Burundi, Uganda, Ethiopia, South Sudan, Canary Islands, Madeira, Azores-Tropical Africa, naturalised in Europe and America.

SPECIMENS EXAMINED. **Cameroon**: Buea: c 1000 m, *Rosevear* 41 (BM); loc. cit., *Rosevear* 37 (BM); loc. cit., 1200 m, *Migeod* 23 (BM, K); loc. cit., *Hambler* 224 (BM); loc. cit., Victoria, *Brenan* 4385 (BM, K); Cameroon Mt, 1500-1800 m, *Box* 3609 (BM); Ubile: Victoria, Mann's Spring, 950 m, *Richards* 4358 (BM, K); Batibo, 1200 m, *Brunt* 1061 (K); No locality, *Mann* 383 (K); **Equatorial Guinea**: Bioko: Ascencion al Pico Serrano, Guinea 2018 (BM); loc. cit., Ilache waterfall, 1200 m, *Adams* 1080 (BM); **South Africa:** Zitzikamma Dist., *Kraus Marks* s.n. (B) Port Natal, *Gueinzius* 307 (isolectotype B).

HABITAT. Frequent on moist, sunny or shaded ground beside paths in lowland and montane rain forests; 600 - 2140 m.

CONSERVATION STATUS: Least Concern (LC). This species is widespread in its distribution, occurring across the continent of Africa, from the West through the Centre and the East to the South. It is also well naturalized in Europe and America.

Selaginella leoneensis Hieron. in Engler & Prantl, Pflanzenfamilien, 1, 4: 697 (1901). Type: Sierra Leone. Freetown, *Brown & Brown* 79 (B200077905, holotype; K000351233, P00466597, isotypes).

Figures 1F, 9.

Plants erect or suberect, main stem branched at the base; branch systems 3-5 pseudopinnate; rhizophores arising at the axils of the primary branches and restricted to the basal third of the plant. Leaves anisophyllous, single-veined; stomata 30 – 36 x 15 –

24 µm; ligules up to 0.24 mm long, obclavate. Lateral leaves asymmetrical, elliptic-oblong, up to 2.8 x 1.3 mm, base oblique, apex acute to weakly mucronulate, margins of basal half short ciliate-serrate (-sub-entire) (cilia up to 0.15 mm long), apical half serrate-serrulate; ligular surface epidermis with isodiametric, sinuous cells, without stomata; aligular surface epidermis with elongate, occasionally isodiametric, sinuous cells, stomata randomly distributed on lamina, SI 14 – 17. Median leaves asymmetrical, lanceolate, up to 1.4 x 0.5 mm, base obtuse to weakly attenuate, apex aristate (aristae up to 3/4 the length of lamina), margins distantly serrate; aligular surface epidermis with isodiametric, sinuous cells, stomata sparsely distributed on lamina, SI 1 – 3. Axillary leaves symmetrical, ovate, up to 2.6 x 1.4 mm, base obtuse, apex broadly acute to sub-obtuse, margins short ciliate-serrate (cilia up to 0.12 mm long); ligular surface epidermis with isodiametric, sinuous cells, without stomata; aligular surface epidermis with elongate, occasionally isodiametric, sinuous cells, stomata randomly distributed on lamina and margins, SI 13 – 16. Strobili bilateral, resupinate, at apices of branchlets, up to 10 mm long, with two sporangial arrangements: (a) cone wholly microsporangiate; (b) with the dorsal side containing both megasporangia and microsporangia randomly arranged and the ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls ovate-sub-panduriform, up to 1.9 x 0.9 mm, base oblique (obtuse-truncate), apex

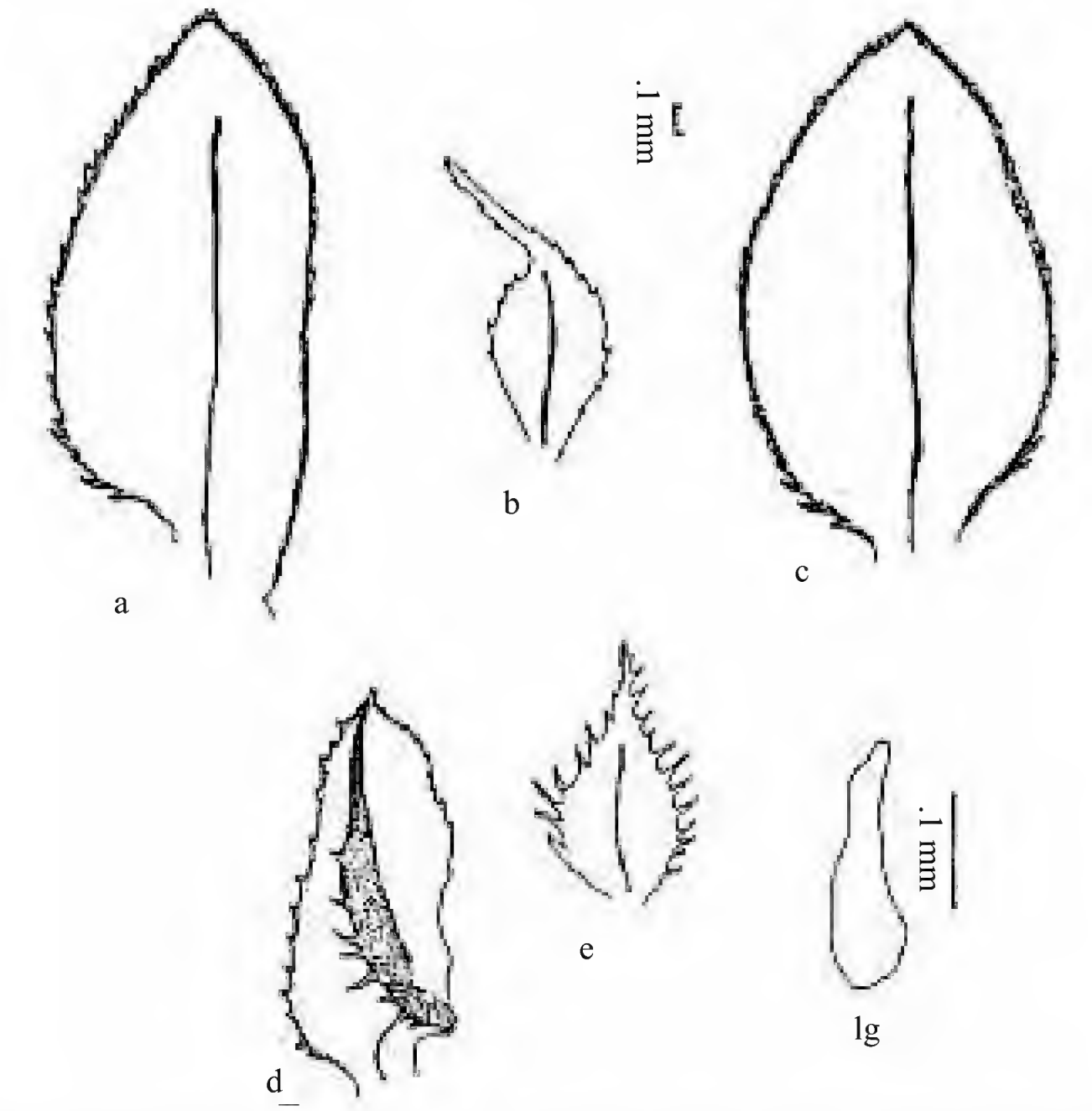

Figure 9. *Selaginella leoneensis* Hieron., a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Harley 161 (BM).

apiculate, margins aculeate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinuous cells, stomata randomly distributed on lamina, SI 7 – 10; aligular surface epidermis with isodiametric, sinuous cells, stomata sparsely distributed on lamina and margins, SI 1 – 2; sporophyll-pteryx with ciliate margin (cilia up to 0.18 mm long), with elongate, sinuous cells, without stomata. Dorsal sporophylls narrowly ovate, up to 1.2 x 0.4 mm, base weakly obtuse, apex cuspidate, margins ciliate (cilia up to 0.20 mm long); both ligular and aligular surfaces epidermis with elongate, weakly sinuous to straight-sided cells, occasionally, stomata sparsely distributed at the apical half on the midvein of the aligular surface epidermis only, SI 2 – 3. Megasporangia ovoid-triangular, with 87% similar-sized and 13% 2L:2S spores; megaspores 190 – (M 220) – 236 µm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces reticulate. Microsporangia ellipsoid; microspores 25 – (M 29) – 34 µm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces granulose-papillate.

RECOGNITION. This species is distinguished by its widely spaced lateral leaves, combined with the short ciliate lateral and axillary leaves and ciliate dorsal sporophylls.

DISTRIBUTION. Guinea, Sierra Leone, Liberia, Ivory Coast, Nigeria, Cameroon.

SPECIMENS EXAMINED. **Sierra Leone**: Colony Peninsula: York Pass, 350 m, *Deighton* 3330 (BM, K); loc. cit., 300 m, *Deighton* 3331 (BM, K); loc. cit., *Deighton* 3326 (BM, K); Colony: Sugar Loaf Mt., c 300 m, *Jones* 346 (BM); loc. cit., *Jones* 347 (BM); Picket Hill, 700 m, *Jones* 324 (BM); Loma Mt., *Morton* 2764 (K) ; Bridge on Waterloo-York path, 950 m, *Melville & Hooker* 4686 (K); Freetown, *Brown & Brown* 79 (holotype B; isotype K); Njala: Taia River bank, 150 m, *Fay* 1050 (NY); No localities: *Lane-Poole* 436 (K), *Hart* s.n. (K); **Liberia**: Kitoma: *Harley* F161 (BM); Bilimu: *Harley* 2099 (BM); loc. cit., *Harley* F108 (K); Vonjama: Wohmen, *Baldwin, Jr.* 10068 (K); **Ivory Coast**: Teke, 40 km N. d'Abidjan, *Abbayes* 295 (BM); Yapo, 45 km N. d'Abidjan, *Abbayes* 258 (BM); Memba, 45 km N. d'Abidjan, *Abbayes* 293 (BM); **Nigeria**: Abakaliki, *Baldwin Jr.* 13811 (BM); Obudu: Sonkwala, Balinge-Ikwette path, *Savory & Keay* FHI 25157 (BM); Ondo: Akure, Idanre, c 300 m, *Savory* UCI 41 (BM); loc. cit., *Richards* 3805 (BM); loc. cit., *Brenan* 3852 (BM); loc. cit., *Keay* FHI 22669 (BM); loc. cit., *Keay* FHI 25497 (BM); loc. cit., *Keay* FHI 25499 (BM); loc. cit., *Jones* 3824 (K); Oyo: Ile Ife, University of Ife Campus, *Hall* 16 (K); **Cameroon**: Bamenda: Bafut, *Savory* UCI 294 (BM); loc. cit., mile 44 from Mamfe, c 450 m, *Keay* FHI 28546 (BM).

HABITAT. On rocks, stones, or ground along paths through forests; also on shaded wet banks in forest; up to 1000 m altitude.

CONSERVATION STATUS: Least Concern (LC). This species is widely distributed across West Africa, with many specimens, examined during this study, collected from many different locations. It has been very recently reported in collections from Togo (Abotsi et al., 2018).

Selaginella molleri Hieron. in Engler & Prantl Pflanzenfamilien, 1, 4: 697 (1901). Type: Sao Tome: Bom Successo, 1250 m, *Moller* 79 (BM000785260, holotype).

Figure 10.

Plants erect or suberect, main stem branched at the base; branch-system 1-2 pseudopinnate; rhizophores arising at the axils of the primary branches and restricted to the basal third of the plant. Leaves anisophyllous, single-veined; stomata 31 – 35 x 15 – 23 µm; ligules up to 0.27 mm long, obclavate. Lateral leaves asymmetrical, ovate-elliptic, up to 2.8 x 1.2 mm, base obtuse, apex acute, margins short-ciliate-serrate (cilia up to

0.13 mm long); ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, sinuous, occasionally isodiametric cells, with sclerotic cells forming patches and bands on lamina, stomata, more or less, evenly distributed on lamina, also on margins, SI 17 – 19 Median leaves asymmetrical, elliptic-ovate to broadly lanceolate, up to 2.0 x 0.8 mm, base oblique (obtuse-cuneate), apex aristate (aristae 2/3 to same length as lamina), margins short-ciliate (cilia up to 0.14 mm long); ligular surface epidermis with elongate, weakly sinuous to straight-sided cells, without stomata; aligular surface epidermis with isodiametric, straight-sided cells, stomata evenly distributed on lamina, also on arista, SI 8 – 9. Axillary leaves symmetrical, ovate, up to 2.6 x 1.4 mm, base obtuse, apex acute to apiculate, margins of basal half short-ciliate (cilia up to 0.13 mm long), apical half serrate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, sinuous to straight-sided cells, stomata, more or less evenly distributed on lamina, also on margins, SI 15 – 19. Strobili

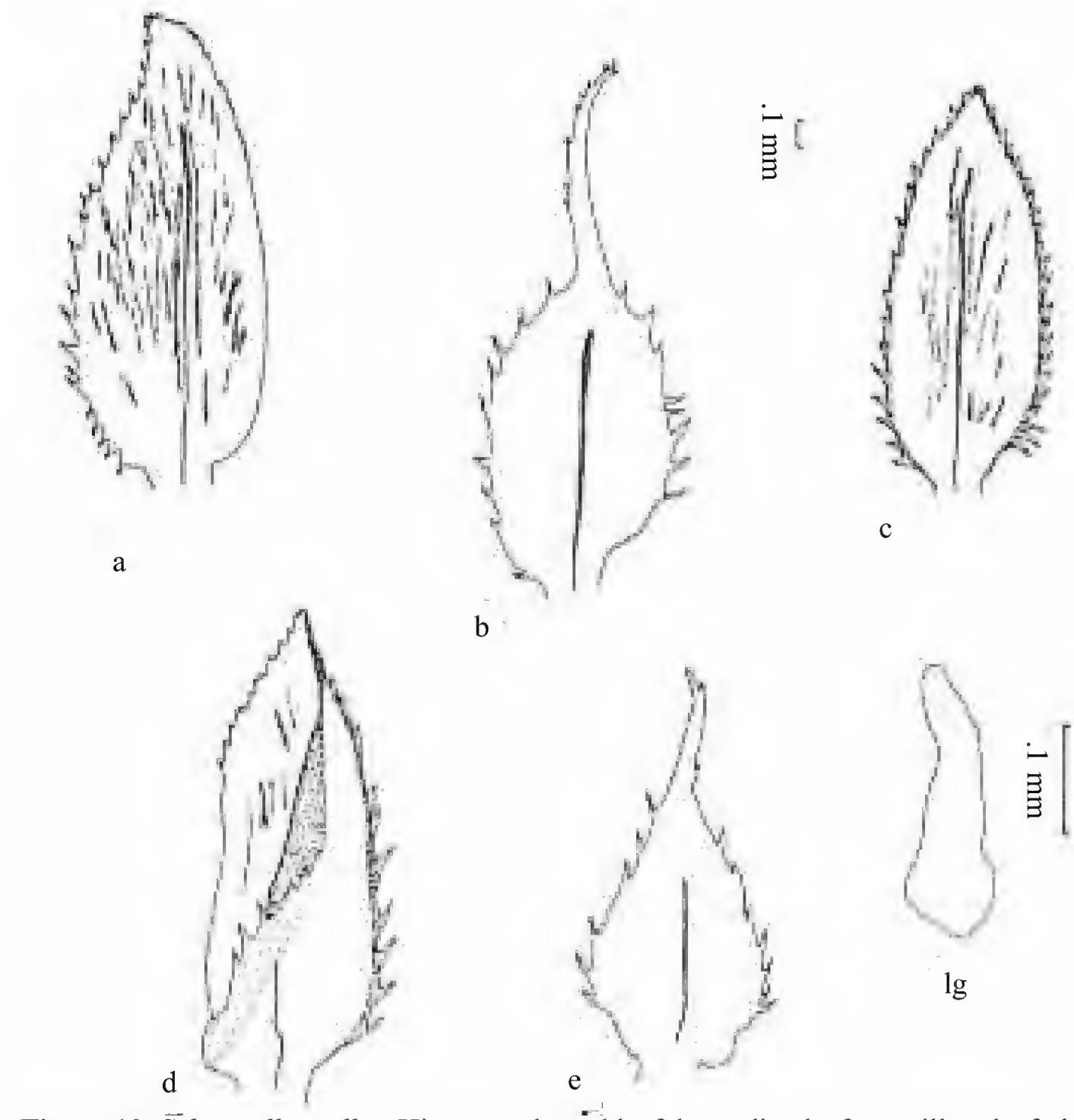

Figure 10. *Selaginella molleri* Hieron., a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Moller 79 (BM, holotype).

bilateral, resupinate, at apices of branches and/or branchlets, with both determinate and intermittent growth patterns, with one sporangial arrangement: cone with dorsal side wholly megasporangiate and ventral side containing both megasporangia and microsporangia randomly arranged. Sporophylls dimorphous. Ventral sporophylls oblong-ovate, up to 2.0 x 1.0 mm, base oblique, apex acute to acuminate, margins short-ciliate-double serrate (cilia up to 0.12 mm long), with complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinuous, occasionally straight-sided cells, stomata randomly distributed on lamina and margins, SI 11 – 14; aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata randomly distributed on lamina, SI 8 – 9; sporophyll-pteryx with short-ciliate margin (cilia up to 0.11 mm long), with elongate, sinuous to straight-sided cells, without stomata. Dorsal sporophylls trullate to ovate, up to 1.5 x 0.8 mm, base subcordate, apex cuspidate, margins short-ciliate (cilia up to 0.12 mm long); both ligular and aligular surfaces epidermis with elongate, weakly sinuous to straight-sided cells, stomata sparsely distributed along the midvein at the apical half of the aligular surface epidermis only, SI 2 – 3. Megasporangia deltoid, with similar-sized spores; megaspores 225 – (M 237) – 280 μm in equatorial diam., trilete, globose, both proximal and distal surfaces rugulose. Microsporangia oblong-ellipsoid; microspores 29 – (M 36) – 40 μm in widest area, trilete, tetrahedral-sub-triangular, both proximal and distal surfaces scabrate-verrucate.

RECOGNITION. *Selaginella molleri* is distinguished from *S. thomensis* by its short ciliate leaves, median leaves with aristate apices and occasional intermittent strobili growth pattern.

DISTRIBUTION. Liberia, Nigeria, Cameroon, Equatorial Guinea (Bioko), Sao Tome.

SPECIMENS EXAMINED. **Nigeria**:Ondo: Orosun, Wanre Hills, c 900 m, *Keay FHI* 25522 (BM), loc. cit., *Keay FHI* 25516 (BM); loc. cit., *Richards* 3785 (K); Between William Camp and Marhai, near Farun Rua, *Hall* 645 (K); Panshanu F.R., 900 m, *Drew* 244 (K); loc. cit., foothill leading to Ziem Peak, 950 m, *Lawlor & Hall* 433 (K); Sardanna: Mambilla Plateau; *Chapman* 100 (K); **Cameroon**: Nyasoso, 800 m, *Thorold* 17 (K); **Equatorial Guinea**: Bioko: Lago Biao, c 1300 m, *Melville* 662 (BM, K). **Sao Tome**: Bom Successo, 1250 m, *Moller* 79 pp (holotype, BM; isotype, K); Macambrara: Vanhulst, c 1100-1300 m, *Exell* 180 (BM); Santa Maria, mule track between Jamar and Santa Maria, c 1300 m, *Exell* 261 (BM).

HABITAT. On mossy rocks, under bushes, on banks in forest and near waterfalls, rarely as an "epiphyte" on tree ferns and other trees; up to 1300 m.

CONSERVATION STATUS: Data Deficient (DD). This species occurs in five countries in West Africa with the latest reported record of it being 1999 (Figueiredo, 2001). According to IUCN Standards and Petitions Subcommittee (2014) "A taxon is a DD category when there is inadequate information to make a direct, or indirect, assessment of a taxon's risk of extinction based on its distribution and/or population status". The limited information on the distribution of this species justifies its DD status.

Selaginella molliceps *Spring* in Memoires de l'Académie Belgique 24: 257 (1850). Type: Principe. *Curror* s.n. (K000351246, holotype).

Figures 1D, 11.

S. rubricaulis Hort. (1859) Type: Angola: Cuanza Norte, Golingo Alto, Altitude, c 800 m, *Welwitsch* 46, 47 (K000351245, holotype; BM0001019846, BM0001019847, isotypes).

Plants suberect to erect; branching from the base, branch-systems 2 - 3 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal third of the plant. Leaves anisophyllous, single-veined; stomata 30 – 39 x 13 – 18 µm; ligules up to 0.38 mm long, elongate obclavate. Lateral leaves asymmetrical, ovate-oblong to elliptic-oblong, up to 3.0 x 1.3 mm, base oblique, apex subobtuse to weakly mucronulate, margins ciliate-serrate (cilia up to 0.25 mm long); ligular surface epidermis with isodiametric, sinuous cells, without stomata; aligular surface epidermis with elongate, sinuous cells, with sclerotic cells forming patches on lamina, stomata concentrated along the midvein in 1 - 2 rows and scattered on the margins, SI 10 – 14. Median leaves asymmetrical, lanceolate, up to 1.7 x 0.7 mm, base obtuse (attenuate), apex cuspidate to aristate (aristae up to 1/3 the length of lamina), margins ciliate-distantly serrate (cilia up to 0.23 mm long); ligular surface epidermis with elongate, sinuous cells, without stomata; aligular surface epidermis with isodiametric, sinuous cells, stomata concentrated along the midvein in 1 – 2 rows and scattered on the margins and on the basal third of arista,

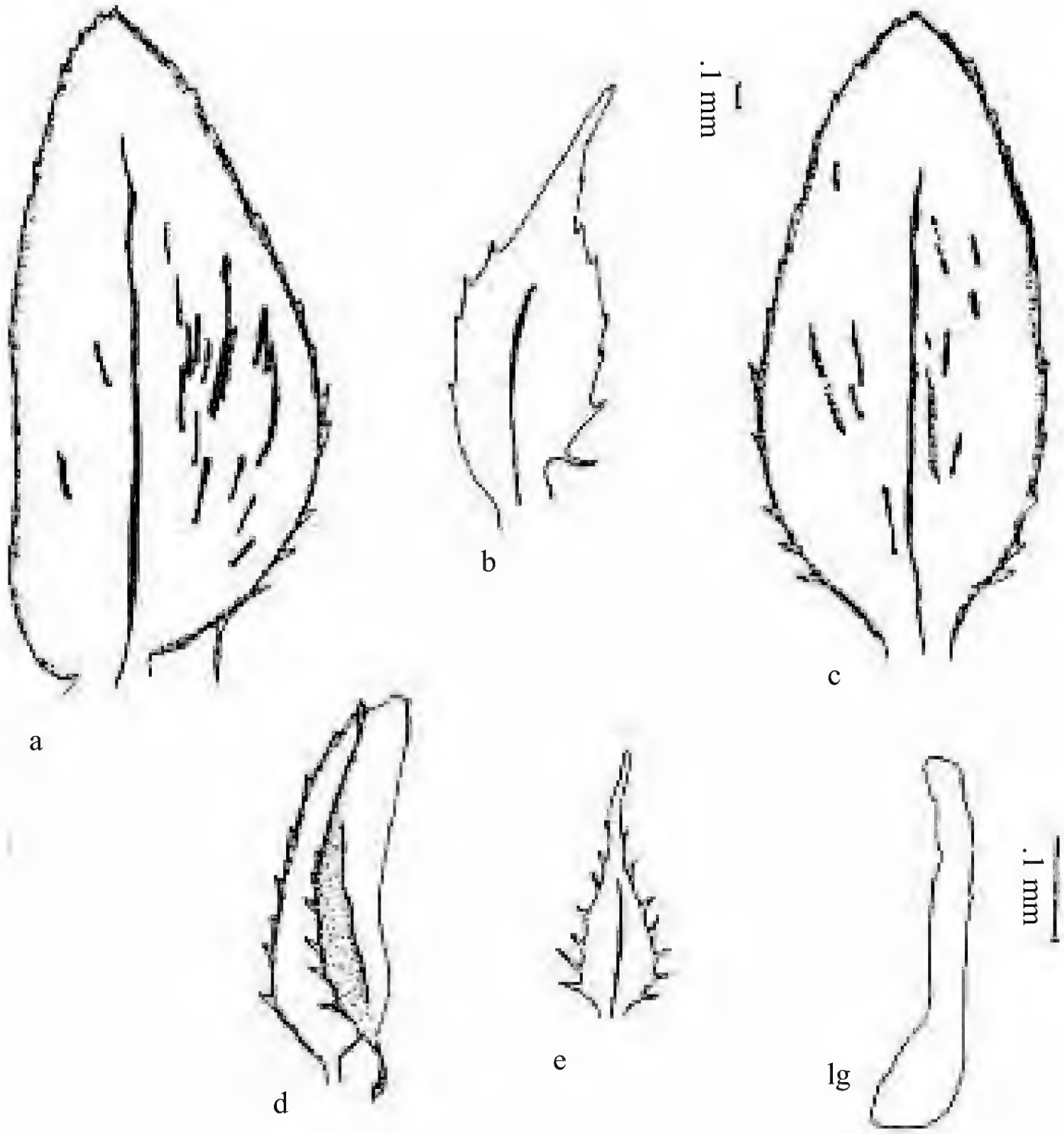

Figure 11. *Selaginella molliceps* Spring, a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Exell 500 (BM).

SI 3 – 5. Axillary leaves symmetrical, elliptic-ovate, up to 2.8 x 1.5 mm, base obtuse, apex broadly acute to subobtuse, margins ciliate at the basal half (cilia up to 0.23 mm long) and serrate at the apical half; ligular surface epidermis with isodiametric, sinuous cells, without stomata; aligular surface epidermis with elongate, sinuous cells, with sclerotic cells forming patches on lamina, stomata concentrated along the midvein in 1 – 3 rows and scattered on the margins, SI 14 – 16. Strobili bilateral, resupinate, at apices of branches and/or branchlets, up to 15 mm long, with four sporangial arrangements: (a) cone wholly megasporangiate; (b) with dorsal side wholly megasporangiate and ventral side wholly microsporangiate; (c) with dorsal side wholly megasporangiate and ventral side containing both megasporangia and microsporangia randomly arranged; (d) cone wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls lanceolate-elliptic, up to 2.1 x 1.0 mm, base oblique, apex subretuse or acute-apiculate, margins short ciliate-serrate (cilia up to 0.13 mm long) to aculeate-subentire, with complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinuous cells, stomata randomly distributed on the lamina of the 'folded' side, SI 6 – 9; aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata sparsely distributed along the margins, SI 1 – 3; sporophyll-pteryx with short ciliate-serrate margin (cilia up to 0.14 mm long), with elongate, sinuous cells and stomata sparsely distributed (1 – 2) at the outer side. Dorsal sporophylls lanceolate, up to 1.2 x 0.4 mm, base obtuse, apex cuspidate to aristate (aristae up to 2/3 the length of lamina), margins ciliate (cilia up 0.20 mm long); ligular surface epidermis with elongate, straight-sided cells, without stomata; aligular surface epidermis with elongate, sinuous cells at the midvein region and elongate, straight-sided cells at the lamina region, stomata more or less evenly distributed along the midvein in 1 – 2 rows, SI 2 – 3. Megasporangia deltoid, with 89% similar-sized and 11% 3L: lS spores; megaspores 185 – (M 240) – 275 μm in equatorial diam., trilete, subglobose, both proximal and distal surfaces reticulate. Microsporangia ellipsoid; microspores 24 – (M 28) – 33 μm in widest area, trilete, tetrahedral-sub-triangular, both proximal and distal surfaces compactly scabrate.

RECOGNITION. This species is very similar to *S. hildebrandtii* from Madagascar from which it is distinguished by its ciliate leaf margins. It is recognised in West Africa by its subretuse ventral sporophylls.

DISTRIBUTION. Guinea, Liberia, Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Equatorial Guinea (RM, Bioko); Sao Tome, Principe, Gabon, Congo, DR Congo, Angola, Uganda.

SPECIMENS EXAMINED. **Guinea**: Dintinn: Fouta-Djallon, 750 m, *Abbayes* 867 (BM); Damane to Nzo Road, Gouee Bridge, 400 m, *Abbayes* 600 (BM). **Liberia**: Webo: Diebla, *Baldwin Jr.* 6288 (BM); Tappita, *Baldwin Jr.* 9103 (BM); **Ivory Coast**: Teke forest, *Abbayes* 296 (BM); **Ghana**: Aburi, c 500 m, *Thompson* 1898 (BM); Nfuom: Kakum F.R., c 200 m, Box 2919 (BM); loc. cit., Box 2862 (BM); loc. cit., c 100 m, Box 2915 (BM); loc. cit., Box 2935 (BM); loc. cit., Box 2855 (BM); Potroasi, *Adams* 183 (BM); Kibi: Puso Puso ravine, c 400 - 500 m, Box 3256 (BM); Foso: Foso-Juaso F. R., c 150 m, Box 2487 (BM); loc. cit., *Scholes* 251 (BM); Akim: Kibi Hills, *Johnson* 506 (K); Dominasi: Dominasi Bridge on River Ankobra, *Hall* 2679 (BM); Awiebo, *Hall* 3389 (BM); No localities: *Irvine* 3537 (BM); *Forte* 49 (BM); **Togo**:. Fomana, c 300 m, Box 2912 (BM); **Nigeria**: Benin: Ehor & Ibekwe, c 100 m, Fairbairn (BM); Bamenda: Bafut-Wum Road, Metchen Falls, *Savory* UCI 313 (BM); Calabar: Kwa Falls, *Richards* 4005 (BM); Ikom: Ogoja, Aboabam, *Keay* FHI 28232 (BM); Mambilla Plateau, *Chapman* 2697 (K); **Cameroon**: Urwaldgebiet: Bipinde, *Zenker* 4104 (BM); Kumba: Banga, S.

Bakundu F.R., *Richards* 4028 (BM, K); Man of War Bay, *Schlechter* 12392 (BM); Barombi: Barombi Station, *Preuss* 305 (BM); Yaounde: Yaounde Station, c 800 m, *Zenker & Staudt* 176 (BM); Bertoua to Yaounde, *Nickles* 123 (BM); Mt. Bamboutos, c 2000 m, *Nickles* 48 (BM); No locality: *Zenker* 1846 (BM); **Equatorial Guinea**: Bioko: Ureka, c 150 m, *Thorold* TF 33A (BM); Mont Balea, Guinea 495 (BM); loc. cit., Guinea 511 (BM); Biao, c 2000 m, *Melville* 468 (BM); 'Fishtown", c 50 m, *Benl & Benl* FP 259 (BM); No locality: *Barter* 1399, 2041 (K); **Angola**: Golungo Alto, c 800 m, *Welwitsch* 46, 47 (BM, K; Type of *S. rubricaulis* Hort. Principe. Pico de Papagaio, c 900 m, *Welwitsch* II (BM, K) ; Oque Pipi, c 300 m, *Exell* 500 (BM).
HABITAT. Usually growing on laterite banks of water-courses in shady forest and on boulders. Also found along paths and roads; primarily reported from rain forests below 1000 m altitude, occasionally found at 2000 m.
CONSERVATION STATUS: Least Concern (LC). This species is widespread in its distribution. It occurs across the continent of Africa; from the West through the Centre to the East and is recently recorded in collections from Togo (Abotsi et al., 2018).

Selaginella myosurus (Sw.) Alston in Journal of Botany, 2:64 no.6 (1932). Type: Sierra Leone. *Afzelius* s.n. (BM000785246, holotype).
Figures 1K, 12.
Stachygynandrum scandens Beauv. Mag. Encycl. 5: 483 (1804)
Selaginella scandens (Beauv.) Spring Bull. Acad. Roy. Sci. Bruxelles. 10: 226 (1843). Type: Nigeria. Beauvois s.n. (G.382619/1).
Plants twining, climbing up to 3 m; branch-system 2 - 3 pseudopinnate; rhizophores arising at the dorsal side and/or axils of primary branches and distributed more or less throughout the plant. Leaves anisophyllous, three veined; stomata 22 – 30 x 18 – 20 m; ligules up to 0.28 mm long, obturbinate. Primary stem leaves sub-symmetrical, ovate to weakly elliptic, up to 3.5 x 1.2 mm, base auriculate, apex acuminate, margins serrate-double-serrate; ligular surface epidermis with slightly elongate, undulating, sinuous cells, without stomata; aligular surface epidermis with slightly elongate, undulating, weakly sinuous cells, stomata concentrated along the midvein in 2 – 4 rows, SI 11 – 13. Lateral leaves asymmetrical, ovate-elliptic to oblong, up to 4.0 x 2.0 mm, base obtuse, apex acuminate, margins serrate-serrulate; ligular surface epidermis with slightly elongate, undulating, weakly sinuous cells, without stomata; aligular surface epidermis with slightly elongate, undulating, weakly sinuous cells, stomata concentrated along the midvein in 3 – 7 rows, SI 19 – 21. Median leaves asymmetrical, lanceolate, up to 2.2 x 0.8mm, base weakly auriculate, apex cuspidate, margins serrate-serrulate; ligular surface epidermis with slightly elongate, sinuous cells, without stomata; aligular surface epidermis with slightly elongate, sinuous cells, stomata concentrated along the midvein in 2-4 rows, SI 11 – 12. Axillary leaves symmetrical, ovate, up to 3.8 x 2.3 mm, base obtuse, apex acuminate, margins serrate-serrulate; ligular surface epidermis with slightly elongate, undulating, weakly sinuous cells, stomata concentrated along the midvein in 2 - 6 rows, SI 7 – 9; aligular surface epidermis with slightly elongate, undulating, weakly sinuous cells, stomata concentrated along the midvein in 3-8 rows, SI 14 – 15. Strobili tetragonous, at apices of branchlets, up to 40 mm long, with one sporangial arrangement: with a single megasporangium at the base, the rest of cone being microsporangiate. Sporophylls uniform (sub-uniform), sub-ovate-trullate, up to 2.1 x 1.0 mm, base obtuse, apex cuspidate, margins serrate-serrulate; both ligular and aligular surfaces epidermis with elongate, undulating, weakly sinuous cells, stomata concentrated along the midvein,

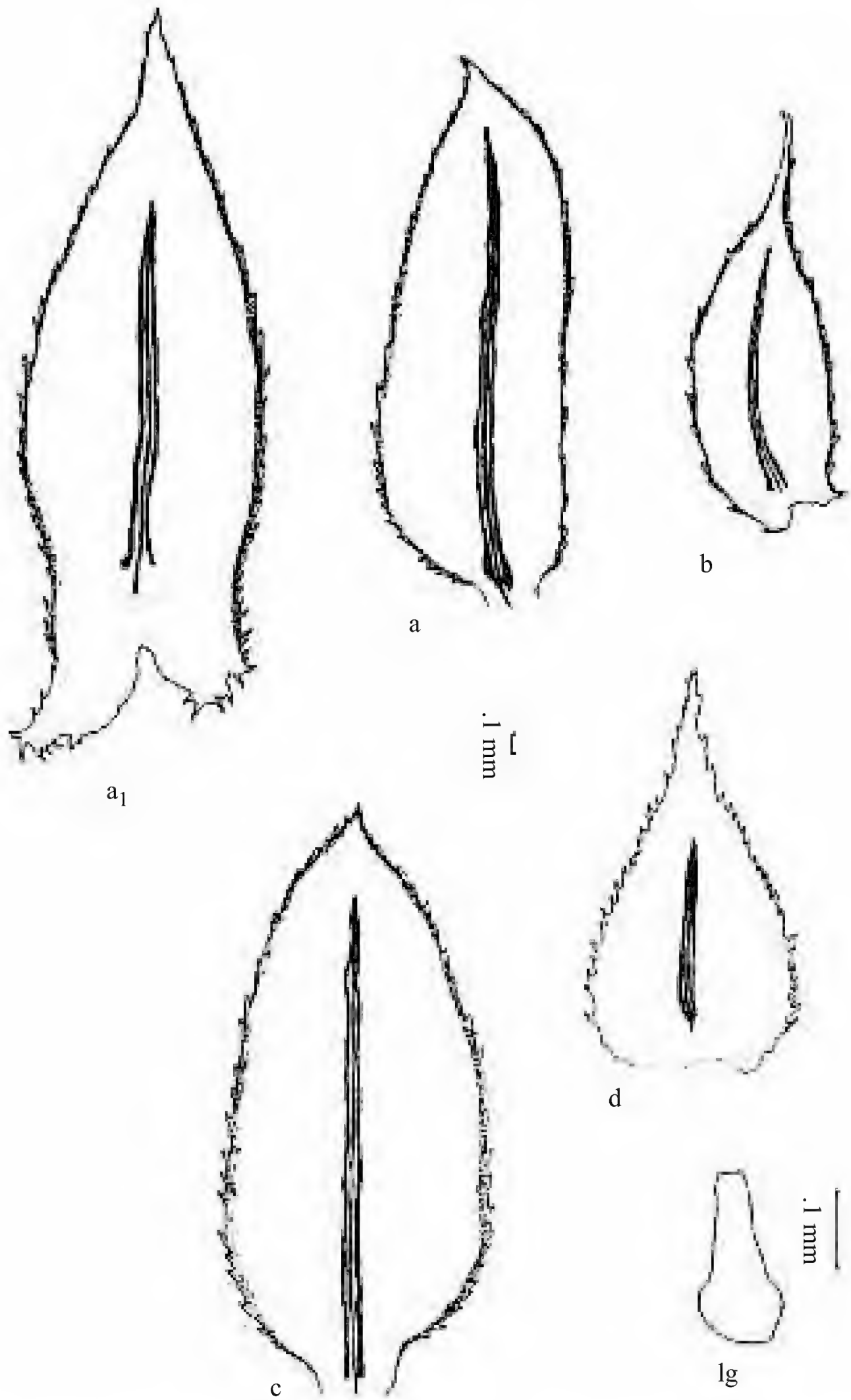

Figure 12. *Selaginella myosurus* (Sw.) Alston, a_1 stem leaf, a. lateral leaf, b. median leaf, c. axillary leaf, d. sporophyll, lg. ligule. All from Gossweiler 7029 (BM).

at the aligular surface only, in 2 –- 5 rows, SI 9 – 10. Megasporangia ovoid-triangular, with 70% similar-sized, 19% 2L: 2S, and 11% 1L:3S spores; megaspores 696 – (M 810) – 941 µm in equatorial diam., trilete, globose, both proximal and distal surfaces solidly striate-reticulate. Microsporangia weakly reniform; microspores 24 – (M33) – 42 µm in equatorial diam., with equatorial flange, trilete, globose, both proximal and distal surfaces verrucate with psilate flanges.

DISTRIBUTION. Senegal, Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Nigeria, Cameroon, Equatorial Guinea (RM, Bioko), Gabon, Congo, DR Congo, Angola, Kenya.

SPECIMENS EXAMINED. **Senegal**: No locality, *Heudelot* 790 (K); *Desvaux* 37 (K). **Guinea:** Rio Benito: Guinea 967 (BM); Nzo: *Schnell* s.n. (K); **Sierra Leone**: Freetown: *Welwitsch* 2 (BM); loc. cit., Nicol Brook, 250 m, *Johnston* s.n. (BM); loc. cit., *Johnston* 29, 31 (K); loc. cit., *Dalziel* 982 (BM, K); Colony, Warm Water river, 50 m, *Melville & Hooker* 610 (K); loc. cit., No 2 river, 8 m, *Melville & Broker* 503 (K); Guma, 220 m, *Hepper & Pyne* 2510 (K); Picket Hill, c 700 m, *Jones* 355 (BM); Sugar Loaf Mt., c 500 m, *Jones* 349 (BM); loc. cit., c 600 m, *Melville* 73 (K); Bule Town, *Melville & Hooker* 367 (K) ; loc. cit., S of Kortright House, *Melville & Hooker* 13 (K); Njala, *Deighton* 2084 (BM, K); loc. cit., (Kori), *Pyne* 1 (K); loc. cit., 150 m, *Fay* 1059, 1075 (NY); Dambaye, Kenema, *Small* 61 (K); Nongowa, Bakshi 19 (K); Peninsula, Leicester Peak, *Morton & Gledhill* 244 (K); Koinaduga, 1.5 km E of Bafodia, 400 m, *Haswell* 92 (K); Between Mansonia and Perankoro, E of Mt. Loma, *Jaeger* 1736 (K); Makumf, 100 m, *Thomas* 901 (K); Kafoko, 200 m, *Thomas* 2117 (K); Bun Kolo (Idolo), 150 m, *Thomas* 1840 (K); Yonibana, 100 m, *Thomas* 5060 (K); Gola North (Garua), *Bakshi* 35 (K); Bendugu (Sengbe), *Bakshi* 13 (K). Matotoka, c 100 m, *Thomas* 1347 (K) ; Potoru (Bari), *Jones* 371 (K); Pejuhun (Panga-Kabonde), *Jackson* 2 (K); Makeni (Bombali Sebora), *Jones* 408 (K); Sherbro Island, *Hunter* s.n. (BM); Heddle's Farm, *Scott-Elliot* 3920 (K); No localities: Afzelius s.n. (BM); *Beauvois* s.n. (BM); Morson s.n. (K); *Barter* s.n. (K) ; Marmo 303 (K); *Thomas* 8668 (K); **Liberia**: Ganta, *Harley* 17 (BM); loc. cit., *Harley* F37 (BM, K); Gbarnga, Linder 446 (K); loc. cit., NE of Suacoco, *Daniel* 402 (BM, K) ; Bolahun, Earthy 17 pp (BM); Vfebo: Nyaake, *Baldwin Jr.* 6216 (BM); Boporo, Zuie, *Baldwin* Jr. 12091 (BM); Monrovia: Firestone Plantations, Dukwai river, *Cooper* 42 (BM, K) ; Montserrado Co., *Baldwin Jr.* 13012 (BM); Port Marshall, c 10m, Kundsen 6 (BM); Nimba Mts., LAMCO compound, 700 m, *Leeuwenberg & Voorhoeve* 4620 (K); loc. cit., *Bos* 2451 (K); Jachere, 450 m, *Adam* 20671 (K); Mt. Bele road, 500 m, *Adames* 482 (K); Between Waimu and Bagoleta, 32 km N of Kakata, *Leeuwenberg & Voorhoeve* 3863 (K); Sinoe Co., *Eggeling* L4 (K); Grand Cape Mount Co., Jabrocca (near Fisherman's Lake), *Baldwin Jr.* 10855 (K); No locality: 600 m, *Adam* 20754 (K); **Ivory Coast**: Mt. Tonkoui, SW of Man, 1180 m, *Leeuwenberg* 2951 (K); loc. cit., 1100 m, *Abbayes* 553 (BM); Mossou, road to Eloka, *Abbayes* 476 (BM); loc. cit., *Porteres* 1556 (K); National Park of Barco, c 5 km NE of Abidjan, *Wilde* 923 (K); Dabou, N of Lopou, *Leeuwenberg* 2321 (K); loc. cit., 16 km W of Dabou, *Boughey GC* 18886 (K); 1.5 km S of Tai off road to Tabou, *Boughey QC* 14964 (K); E of Issia, Boughey GC 14690 (K); **Ghana**: Dixcove, *Box* 2074 (BM); Dunkwa, Cape Coast-Praso road, c 60 m, Box 2062 (BM); Tarkwa, *Vigne* 4125 (K); loc. cit., Subiri F. R., *Andoh FH* 5234 (K); Brawile, near Axim, *Cudjoe* 6 (K); Axim, Akpabla 105 (K); loc. cit., Chipp 415 (K); Aburi Hills, *Obeng* MDA18 (K); Essiama, WR, *Fishlock* 87 (K); loc. cit., *Fishlock* III (K); Atwabo, *Fishlock* 44 (K); Vane, Volta Region, 600 m, *Bigger* 2486 (K); Brenasi, Akim, *Irvine* 552 (K) ; Amedzofe Hill, *Enti* GC 42418 (K); Kumasi, *Cummins* s.n. (K): **Togo**: Klouto, 12 km

NW of Pallme, Hiepko and Schultze-Motel 42 (K); Tomegbe, Badou, 720 m, *Mathey & Scholz* 284 (K).; **Nigeria**: Benin: Sapoba, by Jamieson river, *Richards* 3897 (BM, K); Iyekorhiomwon, Emwiogbon FHI 45337 (K); loc. cit., *Lowe* 1950 (K); loc. cit., *Meikle* 529 (K); Oweri: Mbieri, *Richards* 3960 (K); loc. cit., Richards 3966 (BM); loc. cit., Naze road to Aba, Richards 5136 (BM); Calabar, *Kalbreyer* 47 (BM); loc. cit., *Robb* s.n. (BM) ; loc. cit., on Atimbo road, Onyeachusim and Latilo FHL 48161 (K); Kwa Falls, *Lowe* 2639 (K); Enugu: Onitsha, Joa valley, *Jones* 1076 (BM); Ajalli, c 200 m, *Maggs* 142 (BM, K); loc. cit., Mamu River F. R., *Keay* FHI 22299 (BM); Awka river, Awbibia valley, *Jones* FHI 4543 (K); Pitwood Plantation, on bank of Ekulu stream, *Olorunfemi* FHI 34194 (K); Port Harcourt, New Calabar river, Delta area, *Fraser* 25 (BM); loc. cit., by creek near Golf Course, *Stubbings* 54 (K); Eket, *Talbot & Talbot* s.n. (BM); Usonibge F.R., Urhuehue, *Keay & Onochie* FHI 19669 (K); Umuatia, A. J. C. 242 (K); No localities: *Barter* 44, 2086 (K); *Kennedy* 2701 (K); **Cameroon**: Douala, c 30 m, *Exell* 746 (BM); Yaounde station, Zenker & *Staudt* 186 (BM); Mamfe, 300 m, *Gregory* 244 (K); Urwaldgebiet, Lolodorf, *Staudt* 265 (BM); Bibundi, *Schlechter* 12414 (BM); No localities: *Braun* 7 (BM); *Preuss* 398 (BM); **Equatorial Guinea**: Bioko, *Mann* 1860 (BM); loc. cit., *Mann* 150 (K); Musola, Senicio Agronomico, Guinea 989 (BM). **Angola**: Nzala, S of Belinze-Moriombe, *Gossweiler* 7029 (BM); **DR Congo**: Kinshasa: Kintusi, 100 km S of Kisantu, *Callens* 3892 (BM); Kwango: Kibunda (Mwala), *Callens* 3996 (BM); Yangambi, *Lovis* 14632 (BM).

HABITAT. Prefers sunny sites on road banks, at forest margins, along paths in plantations and secondary woodland; a lowland element, up to 1200 m.

CONSERVATION STATUS: Least Concern (LC). The species has a very large distribution across the continent, from West through the Centre to the East, with many specimens from many different locations, including recent collections (Abotsi et al., 2018).

Selaginella protensa Alston in Mémoires de L'Institut Français d'Afrique Noire 50: 41 (1957). Type: Ivory Coast: top of the Zonque ravine, 1,575 m, Nimba, *R. Portères* s.n. (P004665931, holotype).

Figure 13.

Plants erect or suberect; branch-system 1 - 3 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal quarter of plant. Leaves anisophyllous, single-veined; stomata 38 – 41 x 20 – 23 μm; ligules up to 0.35 mm long, obturbinate. Lateral leaves asymmetrical, ovate-elliptic to deltate-oblong, up to 3.8 x 1.9 mm, base obtuse, apex acuminate, margins of basal half short-ciliate-sub-entire (cilia up to 0.12 mm long), apical half serrate-serrulate; ligular surface epidermis with isodiametric, weakly sinuous to straight-sided cells, without stomata; aligular surface epidermis with elongate, sinuous cells at midvein region and elongate, sinuous to straight-sided cells on lamina, with sclerotic cells forming patches and bands on lamina, stomata randomly distributed on lamina but concentrated along midvein, SI 5 – 10 . Median leaves asymmetrical, ovate-lanceolate, up to 2.3 x 0.8 mm, base obtuse, apex aristate (aristae up to same length as lamina), margins short-ciliate-distantly-serrate (cilia up to 0.12 mm long); ligular surface epidermis with elongate, sinuous cells, without stomata; aligular surface epidermis with isodiametric, sinuous cells, stomata randomly distributed along midvein to the base of aristae, SI 4 – 7. Axillary leaves symmetrical, elliptic to ovate, tip to 3.6 x 2.0 mm, base obtuse, apex acuminate, margins of basal third short-ciliate (cilia up to 0.14 mm long), apical two-thirds serrate; ligular surface epidermis

with isodiametric, polygonal, weakly sinuous to straight-sided cells, without stomata; aligular surface epidermis with elongate, sinuous cells, with sclerotic cells forming patches and bands on lamina, stomata randomly distributed on lamina, SI 12 – 14 . Strobili bilateral, resupinate, at apices of branchlets, up to 6 mm long, with one sporangial arrangement: with dorsal side wholly megasporangiate and ventral sporophylls sterile. Sporophylls dimorphous. Ventral sporophylls ovate-lanceolate, up to 3.2 x 1.2mm, base obtuse, apex cuspidate to long acuminate, margins of basal half short-ciliate-sub-entire (cilia up to 0.13 mm long), apical half aculeate-serrate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinuous cells, stomata sparsely distributed on lamina and margins, SI 3 – 4; aligular surface epidermis with isodiametric, sinuous cells, stomata sparsely distributed on lamina, SI 3 – 4; sporophyll-pteryx with aculeate to short-ciliate margin (cilia up to 0.14 mm long), with elongate, sinuous cells. Dorsal sporophylls lanceolate, up to 1.8 x 0.6 mm, base obtuse, apex cuspidate, margins aculeate-short-ciliate (cilia up to 0.12 mm long); both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata randomly distributed along midvein at aligular surface epidermis only, SI 6 – 9. Megasporangia

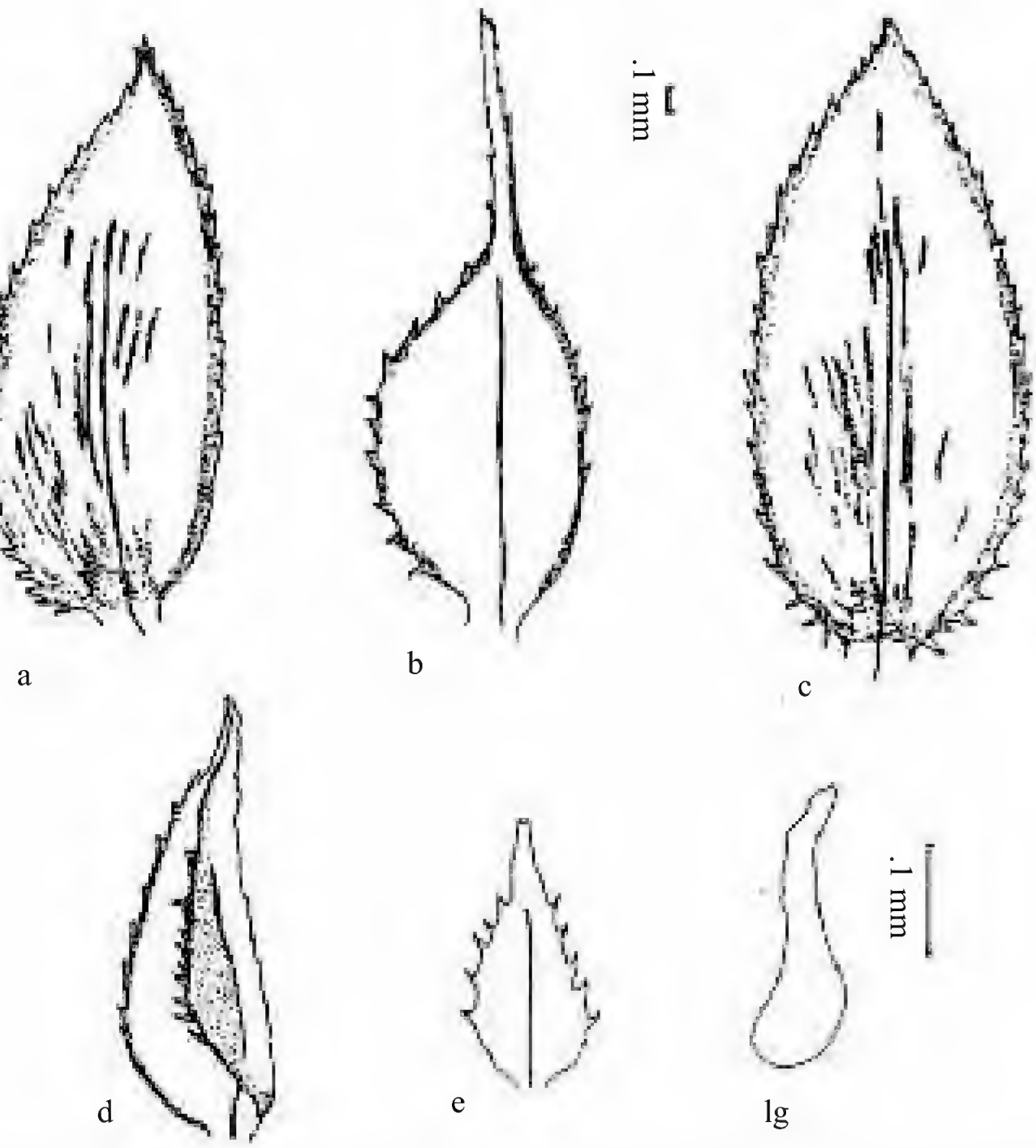

Figure 13. *Selaginella protensa* Alston, a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Portères s.n. (P, holotype).

deltoid, with similar-sized spores; megaspores 210 – (M 254) – 276 µm in equatorial diam., trilete, globose, both proximal and distal surfaces finely reticulate-rugulose. No microsporangia or microspores seen.
RECOGNITION. This species is distinguished by its short ciliate margins and sterile ventral sporophylls.
DISTRIBUTION. Ivory Coast, Togo, Liberia.
SPECIMENS EXAMINED. **Ivory Coast**: Nimba N: ravin du Zouqué, 1575 m, *Portères* s.n. (holotype, P; part of type, BM);
HABITAT. On rocky grounds, up to 1575 m.
CONSERVATION STATUS: Critically Endangered (CR). This species has limited distribution as it is known only from two countries in West Africa. A single specimen was examined during this study. It was last recorded in 1972 in Togo (Abotsi et al., 2018); however, habitat loss of the collected site of Nimba Mt (Bene et al., 2013) justifies the conservation status of CR.

Selaginella serrato-squarrosa Quansah in British Fern Gazette 13 (5): 282, figs 1, 2 (1989). Type: Cameroon: Edea, M. *Nickles* 102 (P00466589, holotype).
Figure 14.
Plants erect or sub-erect; branch-system 3 - 5 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal quarter of the plant. Leaves anisophyllous, single-veined; stomata 31 – 38 x 20 - 26 µm; ligules up to 0.45 mm long, elongate pedate, occasionally bifid. Lateral leaves asymmetrical, sub-subulate to ovate-oblong, up to 5.3 x 1.6 mm, base sub-attenuate to oblique, apex acute, margins of basal third serrate-entire, apical two-thirds entire-subentire; ligular surface epidermis with isodiametric, sinuous cells, stomata randomly distributed near and on the margins of the entire side, SI 8 – 9; aligular surface epidermis with elongate, sinuous cells, with sclerotic cells forming patches and/or bands on lamina, stomata more or less evenly distributed on lamina, SI 14 – 16. Median leaves asymmetrical, lanceolate, up to 4.5 x 1.1 mm, base oblique (obtuse-cuneate), apex long-aristate (aristae up to 2 times the length of lamina), margins serrate; ligular surface epidermis with elongate, sinuous cells, without stomata; aligular surface epidermis with isodiametric, sinuous cells, stomata randomly distributed on lamina and basal third of arista, SI 7 – 8. Axillary leaves symmetrical, ovate to narrowly deltate, up to 5.0 x 1.8 mm, base truncate to weakly subcordate, apex acute, margins of basal half serrate, apical half entire; ligular surface epidermis with isodiametric, sinuous cells, without stomata; aligular surface epidermis with elongate, sinuous cells, stomata evenly distributed on lamina, SI 16 – 18. Strobili bilateral, resupinate, at apices of branchlets, up to 5 mm long, with two sporangial arrangements: (a) cone wholly microsporangiate; (b) with dorsal side containing both megasporangia and microsporangia randomly arranged and the ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls subpanduriform-ovate, up to 2.4 x 1.0 mm, base obtuse, apex acute, margins serrate-entire to aculeate-entire, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinuous cells, stomata randomly distributed on lamina and margins, SI 8 – 11; aligular surface epidermis with isodiametric, sinuous cells, stomata sparsely distributed on lamina, SI 2 – 3; sporophyll-pteryx with serrate margin, with elongate, straight-sided cells, with stomata (1 - 3) distributed on the outer side. Dorsal sporophylls lanceolate, up to 1.2 x 0.6 mm, base obutse, apex cuspidate to aristate (aristae up to same length as lamina), margins serrate; both ligular and aligular surfaces epidermis with elongate, straight-sided

cells, stomata randomly distributed on the lamina at the aligular surface epidermis only, SI 2 – 4. Megasporangia ovoid-triangular, with similar-sized spores; megaspores 210 – (M 220) – 255 µm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces rugulose. Microsporangia ellipsoid to roundish; microspores 15 – (M 19) – 28 µm in widest area, trilete, sub-triangular, both proximal and distal surface granulose to foveolate.

RECOGNITION. This species is very similar to *S. squarrosa* from which it is

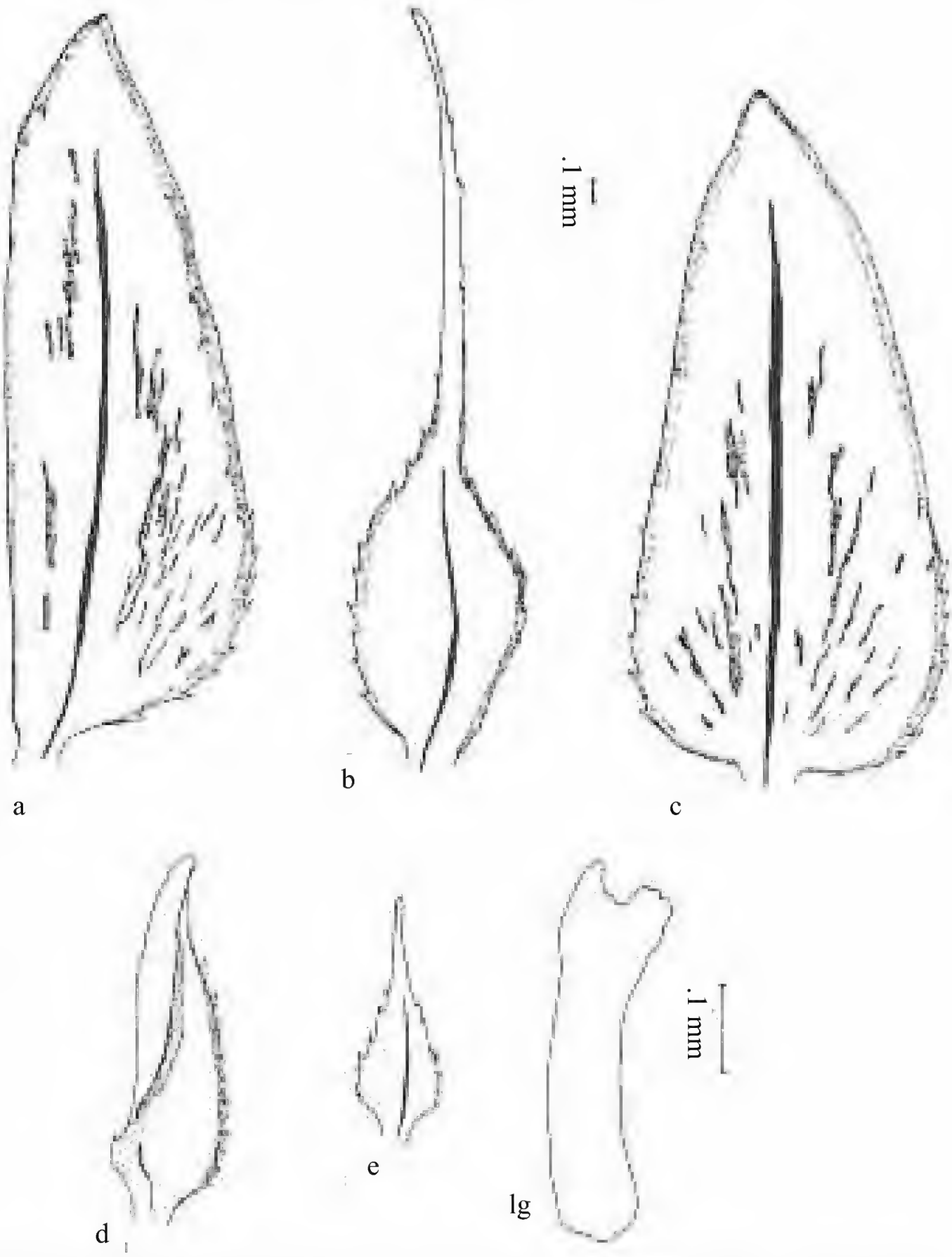

Figure 14. *Selaginella serrato-squarrosa* Quansah, a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Nickles 102 (P, isotype).

distinguished by its serrate-margined leaves and very long aristate median leaves.
DISTRIBUTION. Cameroon, Gabon.
SPECIMENS EXAMINED. **Cameroon**: Edea, *Nickles* 102 (P, holotype). **Gabon**: Nkan: NE Mela, Mont de Cristal, *Halle & Villiers* 4788.
HABITAT. On wet forest floor; up to 1500 m.
CONSERVATION STATUS: Vulnerable (VU D2). This species has limited distribution and it is only known from two specimens from two countries in West Africa. The two specimens were examined during this study. The loss of habitat at Edea threatens the existence of this species, hence, the VU D2 status.

Selaginella soyauxii Hieron. in Die natürlichen. Pflanzenfamilien. 1, 4: 697, 698 (Nov. 1901) no. 305 (1901). Type: Gabon. Prés Munda: Sibange-Farm, *H. Soyaux* 419 (B200130256, lectotype) designated by Verdcourt (2005: 20); (B200077902, B200130258, P00466583, P00466584, P00466586, isolectotypes): "Auf der Karrrfelden der Sibange-farm bei Gabum, West Africa, 26-28.II. 1980" *M. Dinklage* 563 (B20 00779031, syn.); "Senssodri, Quaqua, Dec. 74", *C.Bucholz s.n* (B200077900!, B20 0077904!, K000351240!. P00477916! Syn).
Figures 2J, 15.
Plants prostrate-ascendent; branch system 2 – 3 pseudopinnate; rhizophores arising at the axils and/or dorsal side of primary branches and distributed more or less throughout the plant. Leaves anisophyllous, single-veined; stomata 31 – 36 x 19 – 26 μm; ligules up to 0.28 mm long, pedate occasionally bifid. Lateral leaves asymmetrical, elliptic-oblong to ovate-oblong, up to 4.5 x 2.0 mm, base oblique, apex acute to acuminate, margins of basal half entire, apical half serrate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, sinuous cells, stomata randomly distributed on lamina and along the midvein, SI 13 – 16. Median leaves asymmetrical, obovate, up to 2.5 x 1.5mm, base sub-cuneate to obtuse, apex caudate, margins entire (sub-entire); ligular surface epidermis with elongate, sinuous cells, without stomata; aligular surface epidermis with isodiametric, polygonal, weakly sinuous to straight-sided cells, stomata randomly distributed along the midvein, lamina and margins, SI 8 – 9. Axillary leaves symmetrical, oblanceolate, up to 4.0 x 2.2 mm, base attenuate, apex acute, margins of basal half entire (sub-entire), apical half serrate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, sinuous cells, stomata randomly distributed on lamina, SI 16 – 20. Strobili bilateral, resupinate, at apices of branchlets, up to 8.5 mm long, with two sporangial arrangements: (a) with no particular pattern, (b) with dorsal side containing both megasporangia and microsporangia randomly arrranged and ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls oblong-ovate, up to 3.0 x 1.5 mm, base oblique to sub-obtuse, apex acuminate, margins entire-aculeate with complete sporophyll-pteryx on the adaxial surface; ligular surface epidermis with elongate, weakly sinuous cells, stomata sparsely distributed on lamina, SI 6 – 8; aligular surface epidermis with isodiametric, weakly sinuous to straight-sided cells, stomata sparsely distributed on lamina, SI 3 – 4; sporophyll-pteryx with serrate-sub-entire margin, with elongate, weakly sinuous cells, stomata occasionally present on the outer side. Dorsal sporophylls elliptic-ovate, keeled up to 2.1 x 1.1 mm, base sub-obtuse, apex cuspidate to long acuminate, margins serrate-sub-entire; both ligular and aligular surfaces epidermis with elongate, weakly sinuous cells, stomata sparsely distributed on lamina at aligular surface

epidermis only, SI 2 – 4. Megasporangia deltoid, with 86% similar-sized, 8% 2L: 2S, and 6% 3L:1S spores; megaspores 383 – (M 400) – 430 μm in equatorial diam., trilete, globose to sub-globose, both proximal and distal surfaces psilate. Microsporangia reniform; microspore 34 – (M 38) – 41 μm in equatorial diam., trilete, subglobose, both proximal and distal surfaces echinate on verrucate perispore (verrucate-echinate).
RECOGNITION. *Selaginella soyauxii* is distinguished from other species by its obovate median leaves and pedate ligules.
DISTRIBUTION. Guinea, Sierra Leone, Liberia, Ivory Coast, Togo, Benin, Burundi, Cameroon, Equatorial Guinea (Bioko), Gabon, Congo, DR Congo, Uganda - Tropical regions in Africa.
SPECIMENS EXAMINED. **Sierra Leone**: Between Mattru and Gbangbama, *Deighton* 2341 (K); Kenema: Saama Village, *Scurlock* 15 (K); Denkali: Loma Mts., *Jaeger* 255

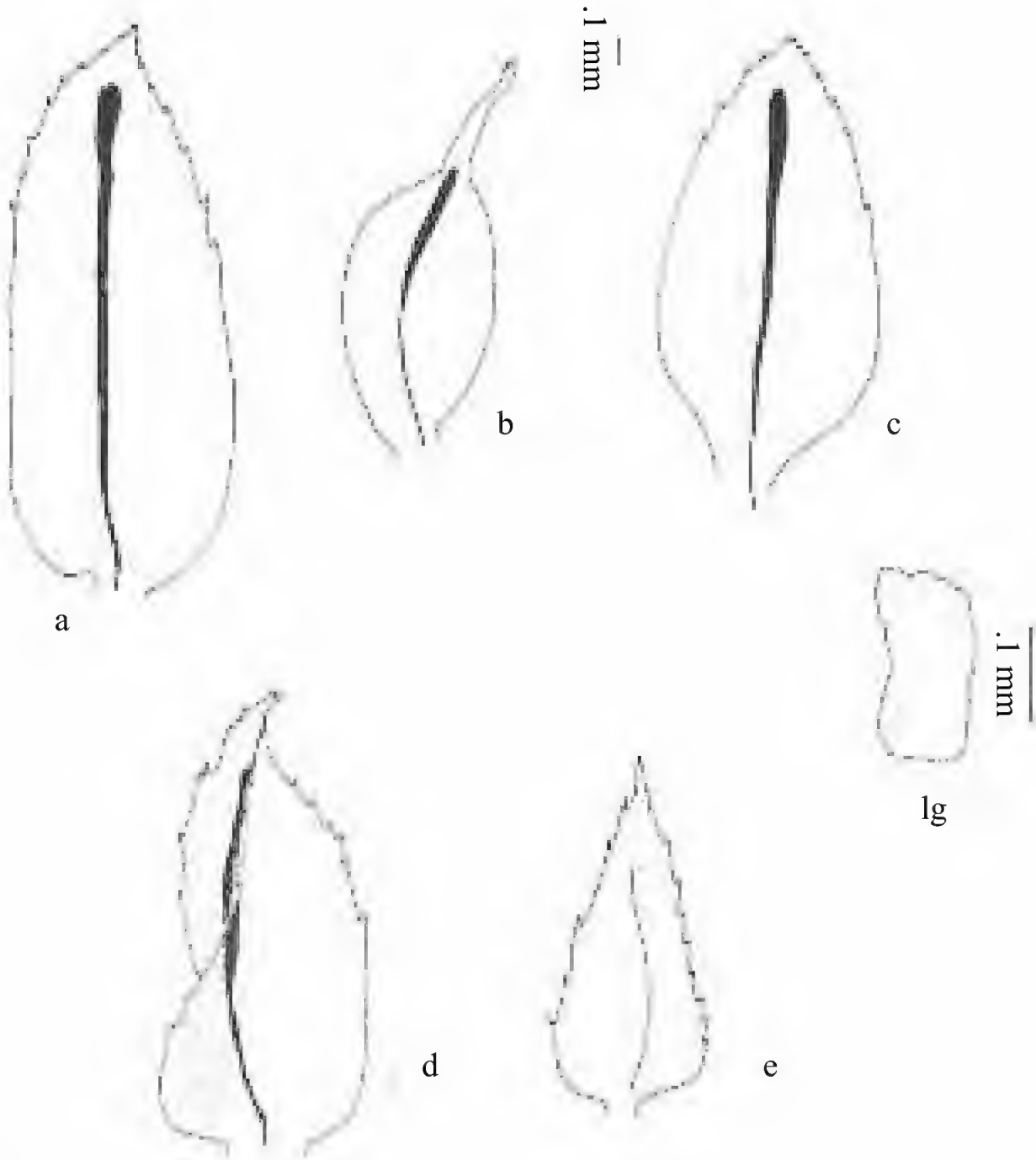

Figure 15. *Selaginella soyauxii* Hieron., a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Soyaux 319 (K, holotype).

(K); Jau (Tunkia), *Deighton* 5221 (K); Giewahun, *Deighton* 458 (K); Kasewe F. R., 150 m, *Fay* 1090 (NY); loc. cit., *Morton* 1481 (K); **Liberia**: Bilimu: *Harley* 2098 (BM); Bolahun: *Earthy* 17 pp (BM); loc. cit., *Earthy* Misc I (BM); **Ivory Coast**: Danane: *Schnell* (BM); Man: Mt. Tonkoui, 1050m, *Abbayes* 230 (BM); **Cameroon**: Bamenda; Bafut, *Savory* UCI 295 (BM); Mopenja: c 800 m, *Kalbreyer* 102 (BM); Buea: c 950 m, *Rosevear* Cam 37/37 (BM); loc. cit., c 900 m, *Migeod* 6 (BM); Signal Hill, 1000 m, *Tryon & Tryon* 6471 (K); Forestry Plantation, 1100 m, *Tryon & Tryon* s.n. (K); Cameroon Mt., 1000 m, *Dunlap* 143 (K); **Equatorial Guinea**: Bioko: Iladyi, c 1180 m, *Benl & Benl* FP 129 (K); Musola: Sewicio Agronomico, Guinea 1313 (BM). **Gabon**: Munda, Sibange Farm, *Soyaux* 419 (K holotype; B isotype).

HABITAT. Prefers moist and shady sites (rocks and banks) in forests, mostly in lower montane zones, from 200 to 1200 m altitude.

CONSERVATION STATUS: Least Concern (LC). The species is widely distributed in the Tropical regions of Africa, with many specimens known from many different locations from West to East across the continent, including recent collections (Abotsi et al., 2018).

Selaginella squarrosa Baker in Journal of Botany, British and Foreign 1885: 180 (1885a) 23: 180 no. 276 (1885). Type: Cameroon: Cameroon Mt., 1000 m, *G. Mann* 1407 (K000351241 holoype; B200130252, syntype.).

Figures 2L, 16.

Plants erect, ascendent; branch system 2 - 4 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal third of the plant. Leaves anisophyllous, single-veined; stomata 30 – 35 x 20 – 25 µm; ligules up to 0.46 mm long, broadly clavate. Lateral leaves asymmetrical, deltate-sub-oblong, up to 5.1 x 1.7 mm, base sub-obtuse to oblique, apex acute to weakly mucronulate, margins entire (sub-entire); ligular surface epidermis with isodiametric, polygonal, sinuous to straight-sided cells, stomata randomly distributed on the margin of the sub-oblong side, SI 8 – 10; aligular surface epidermis with elongate, sinuous cells with sclerotic cells forming patches on lamina, stomata, more or less, evenly distributed along the midvein, SI 14 – 16. Median leaves asymmetrical, ovate, up to 4.2 x 1.2 mm, base obtuse, apex aristate (aristae up to 1.5 times as long as lamina), margins entire; ligular surface epidermis with elongate, sinuous cells, without stomata; aligular surface epidermis with isodiametric, sinuous cells, stomata concentrated along the midvein at the apical half of the leaf (not on arista), SI 4 – 6. Axillary leaves symmetrical, narrowly ovate, up to 4.8 x 1.8 mm, base obtuse, apex acute to weakly mucronulate, margins entire; ligular surface epidermis with isodiametric, polygonal, sinuous to straight-sided cells, without stomata; aligular surface epidermis with elongate, sinuous cells, with sclerotic cells forming patches on lamina, stomata evenly distributed on lamina and along the midvein, SI 11- 13. Strobili bilateral, resupinate, at apices of branchlets, up to 6 mm long, with one sporangial arrangement: cone with dorsal side containing both megasporangia and microsporangia randomly arranged and ventral side wholly microsporangiate. Sporophylls dimorphous. Ventral sporophylls sub-panduriform-deltate, up to 2.2 x 1.0 mm, base oblique, apex acute, margins entire, with a complete sporophyll-pteryx at adaxial surface; ligular surface epidermis with elongate sinuous cells, stomata randomly distributed on lamina of the 'folded" side, SI 13 – 15; aligular surface epidermis with isodiametric, sinuous cells, occasionally with sclerotic cells forming patches on lamina, stomata sparsely distributed on margin of the 'folded' side, SI 1 – 2; sporophyll-pteryx with entire margin,

with elongate, straight-sided cells, without stomata. Dorsal sporophylls ovate, up to 1.6 x 0.9 mm, base obtuse, apex cuspidate, margins serrate-sub-entire (serrate at middle-third region); both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata sparsely distributed along midvein at aligular surface epidermis only, SI 1 – 2. Megasporangia ovoid, with similar-sized spores; megaspores 190 – (M 205) – 245 µm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces reticulate-rugulose. Microsporangia ellipsoid; microspores 20 – (M24) – 26 µm in widest area,

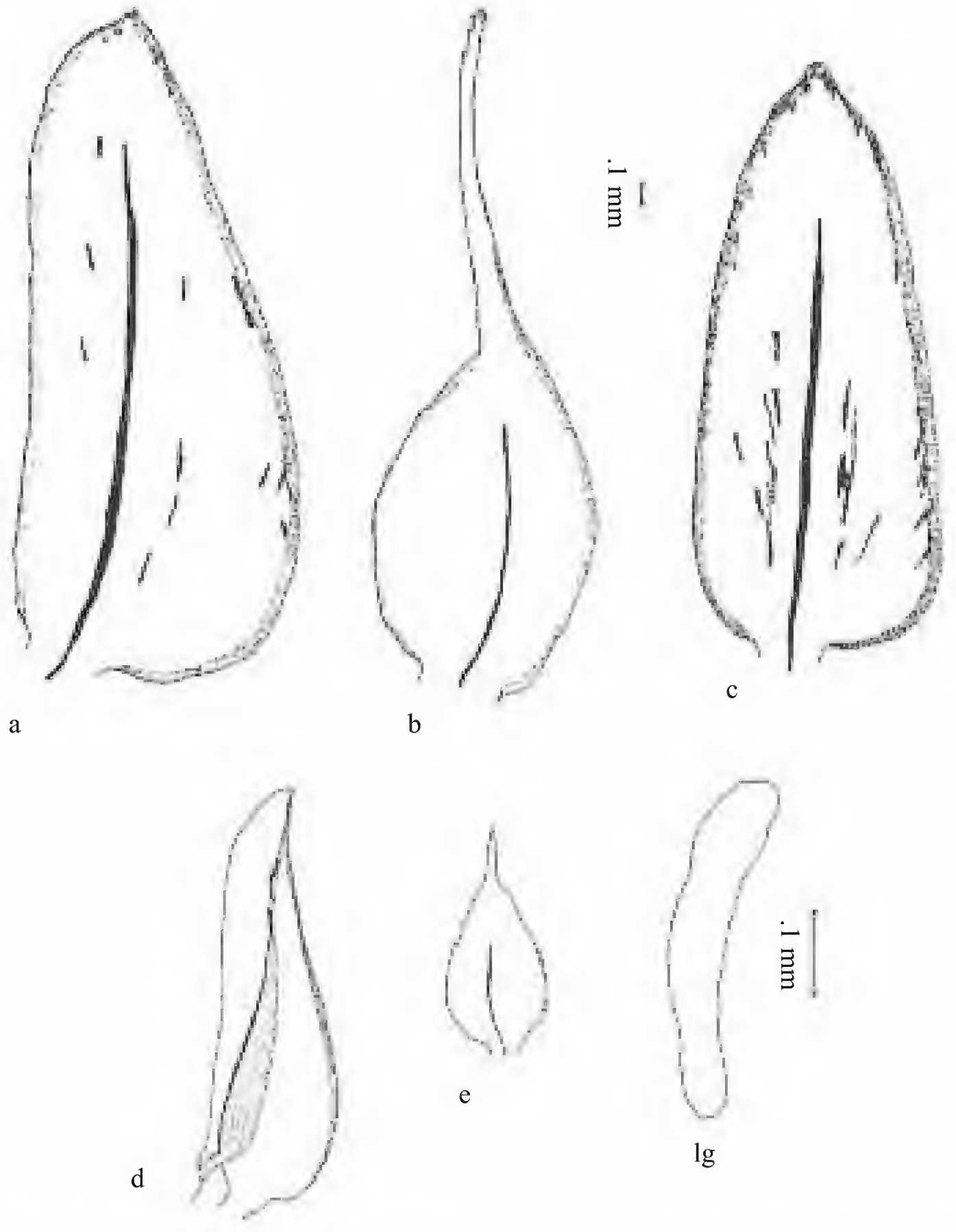

Figure 16. *Selaginella squarrosa* Baker, a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Mann 1407 (K, holotype).

trilete, sub-triangular-tetrahedral, both proximal and distal surfaces scabrate.
DISTRIBUTION. Equatorial Guinea, Cameroon, Principe.
SPECIMENS EXAMINED. **Cameroon**: Cameroon Mt., 1000 m, *Mann* 1407 (holotype, K).
HABITAT. On wet forest floor, up to 1400 m.
CONSERVATION STATUS: Data Deficient (DD). This species is found in two countries, with a single specimen examined during this study.

Selaginella subcordata Braun ex Kuhn, Filices Africanae; fr. 193 (1868). Type: Sierra Leone. Freetown, Sept. 1853, *E.M.J. Welwitsch* 3 (B200130253, holotype; K000351232,

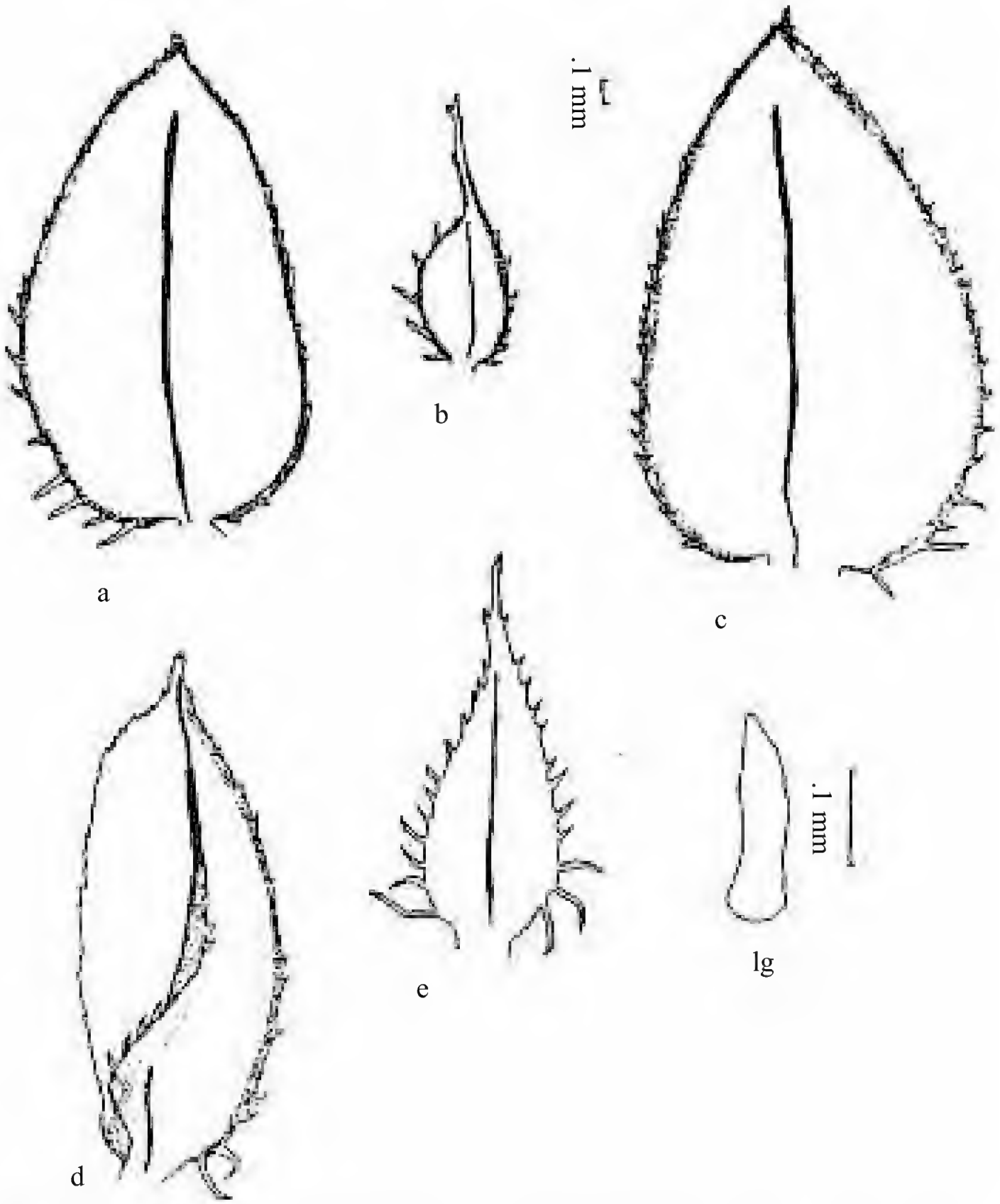

Figure 17. *Selaginella subcordata* A. Br. ex Kuhn, a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Deighton 3087B (BM).

P00466587, isotypes).
Figures 2H, 17.
Plants erect or sub-erect, with a simple unbranched stem or main stem branched from the base, branch-systems 1 - 3 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal third of the plant. Leaves anisophyllous, single-veined; stomata 26 – 30 x 10 – 24 µm; ligules up to 0.24 mm long, narrowly sub-obclavate. Lateral leaves asymmetrical, weakly deltate, up to 2.5 x 1.3 mm, base cordate-subcordate, apex acuminate, margins of basal half ciliate-serrate (cilia up to 0.22 mm long), apical half serrate; ligular surface epidermis with isodiametric, sinuous cells, without stomata; aligular surface epidermis with elongate, sinuous to undulating cells, stomata randomly distributed along the midvein and margins, SI 11 – 12. Median leaves asymmetrical, ovate-lanceolate, keeled, up to 1.3 x 0.6 mm, base sub-obtuse, apex aristate (aristae up to 2/3 the length of lamina), margins short-ciliate-serrate (cilia up to 0.15 mm long); ligular surface epidermis with elongate, sinuous cells, without stomata; aligular surface epidermis with isodiametric, sinuous cells, stomata sparsely distributed on lamina, SI 3 – 4. Axillary leaves symmetrical, ovate to weakly deltate, up to 2.5 x 1.5 mm, base cordate, apex apiculate, margins of basal third ciliate (cilia up to 0.24 mm long), apical two-thirds serrate-serrulate; ligular surface epidermis with isodiametric, sinuous cells, without stomata; aligular surface epidermis with elongate, sinuous to undulating cells, stomata randomly distributed on lamina and margins, SI 10 – 12. Strobili bilateral, resupinate, at apices of branchlets, up to 4.3 mm long, with two sporangial arrangements: (a) with dorsal side wholly megasporangiate and ventral side with sterile sporophylls, (b) with dorsal side containing both megasporangia and microsporangia randomly arranged and ventral side with sterile sporophylls. Sporophylls dimorphous. Ventral sporophylls oblong-elliptic, up to 2.2 x 1.1 mm, base obtuse, apex acuminate, margins of basal quarter ciliate (cilia up to 0.25 mm long), apical 3/4 aculeate-denticulate, with a complete sporophyll-pteryx on the adaxial surface; ligular surface epidermis with elongate, sinuous cells, stomata randomly distributed on lamina, SI 8 – 9; aligular surface epidermis with isodiametric, sinuous cells, stomata sparsely distributed on and/or towards the margins, SI 4 – 5; sporophyll-pteryx with ciliate-serrate margin (cilia up to 0.24 mm long), with elongate, sinuous to straight-sided cells, without stomata. Dorsal sporophylls ovate, up to 1.6 x 0.7 mm, base obtuse, apex cuspidate, margins long-ciliate (cilia up to 0.35 mm long); both ligular and aligular surfaces epidermis with elongate, sinuous to straight-sided cells, stomata sparsely distributed along midvein at the apical third of the aligular surface epidermis only, SI 6 – 7. Megasporangia ovoid-triangular, with 89% similar-sized and 11% 3L:1S spores; megaspores 200 – (M230) – 255 µm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces rugulose. Microsporangia roundish; microspores 30 – (M 38) – 42 µm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces verrucate-clavate.
RECOGNITION. *Selaginella subcordata* is distinguished by its keeled median leaves, lateral leaves with acuminate apices, dorsal sporophylls with long ciliate margins and sterile ventral sporophylls.
SPECIMENS EXAMINED. **Guinea**: Dalabo: *Schnell* 7011 (BM, K); loc. cit., Fouta-Djallon, *Abbayes* 814 (BM); Gouee: *Abbayes* 599 (BM); Mt Kakoulima: Schnell 7538 (BM); **Sierra Leone**: Freetown: *Welwitsch* 3 (holotype, BM; isotype, K); loc. cit., *Lewis* s.n. (BM); Mano: Njala, *Deighton* 3087A, 3087B (BM); Colony Peninsula: York, *Deighton* 3292 (BM,K); Kanga: 500 m, *Thomas* 2971 (K); Waterloo: *Melville & Hooker* 266 (K); Hill Station: *Deighton* 528 (K); Loma Mt., *Morton* 2761 (K); loc. cit., *Jaeger*

231, 1578, 2033 (K); Musaia: Agric. Station, c 400 m, *Sellar* B15 (BM). **Liberia:** Boporo: Tawata, *Baldwin, Jr.* 10348 (BM, K): Sanniquellie: Sacampa Village, *Winne* 77 (BM); Jamesville: *Harley* F209 (BM): **Ivory Coast:** Man: Mt. Tonkoui, 1050 m, *Abbayes* 231 (BM), Seguela, *Ake Assi* 6671 (K); **Ghana**: Damongo: *Hall* 831 (BM).
DISTRIBUTION. Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Congo.
CONSERVATION STATUS: Least Concern (LC). The species is widely distributed, with specimens from many different locations across West Africa.

Selaginella tenerrima A.Braun ex Kuhn, Filices africanae, 193, 194 (1868). Type: Angola: Golingo Alto, 1856, *F.M.J. Welwitsch* 45 (BM000785259, holotype; K000351260, LISU, P00507721, isotypes). Figures 1C, 18.
Plants erect or sub-erect, tufted; main stem branched at base; branch-system 1 - 3 pseudopinnate; rhizophores arising at axils of primary branches and restricted to basal quarter of plant. Plants sometimes unbranched. Leaves anisophyllous, single-veined; stomata 26 – 35 x 19 – 25 μm; ligules up to 0.17 mm long, obclavate, occasionally with

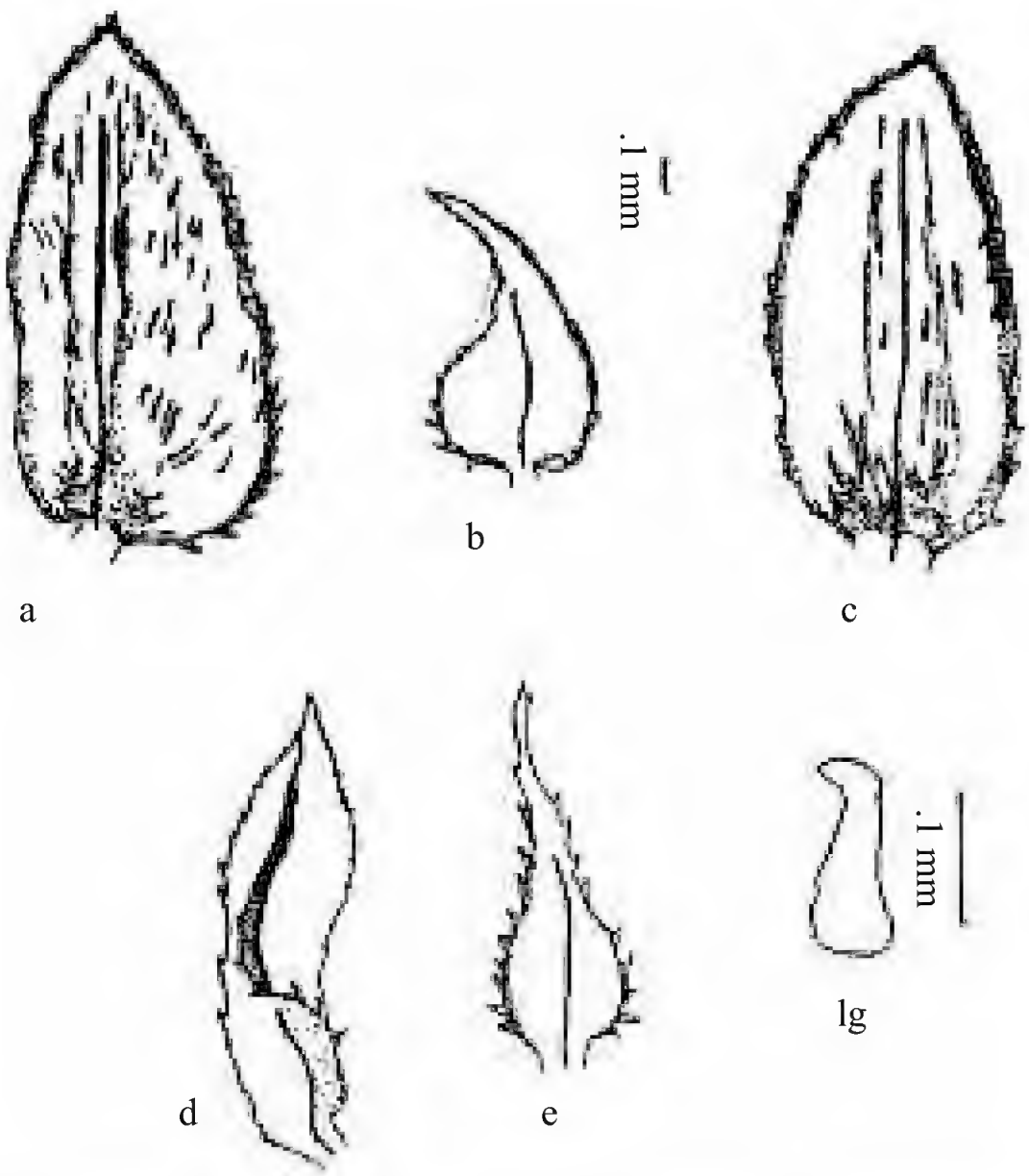

Figure 18. *Selaginella tenerrima* A.Br. ex Kuhn, a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Welwitsch 45 (BM, holotype).

a curved tip. Lateral leaves asymmetrical, ovate-oblong, up to 2.3 x 1.0 mm, base oblique (subcordate-obtuse), apex acute to apiculate, margins of basal half serrate-sub-entire, apical half serrate; ligular surface epidermis with isodiametric, straight-sided cells, without stomata; aligular surface epidermis with elongate, sinuous to straight-sided cells, with sclerotic cells forming patches and bands on lamina, stomata evenly distributed on lamina and margins, SI 18 – 20. Median leaves asymmetrical, narrowly deltate, up to 1.0 x 0.5 mm, base oblique (subcordate-truncate), apex cuspidate, margins serrate-aculeate; ligular surface epidermis with elongate, weakly sinuous to straight-sided cells, without stomata; aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata concentrated along midvein, SI 2 – 4. Axillary leaves symmetrical, ovate-elliptic, up to 2.0 x 1.1 mm, base obtuse, apex mucronulate to acute, margins serrate-serrulate; ligular surface epidermis with isodiametric, weakly sinuous to straight-sided cells, without stomata; aligular surface epidermis with elongate, sinuous to straight-sided cells, with sclerotic cells forming patches and bands on lamina, stomata evenly distributed on lamina and margins, SI 13 – 15. Strobili bilateral, resupinate, at apices of branches and/or branchlets, up to 5 mm long, with two sporangial arrangements: (a) cone wholly megasporangiate; (b) with dorsal side wholly megasporangiate and ventral side containing both megasporangia and microsporangia randomly arranged. Sporophylls dimorphous. Ventral sporophylls sub-panduriform-elliptic, up to 1.9 x 0.7 mm, base obtuse, apex acuminate, margins serrate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinuous cells, stomata randomly distributed on lamina and margin, SI 9 – 10 aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata sparsely distributed on margins, SI 1 – 2; sporophyll-pteryx with aculeate-serrate margin, with elongate, sinuous to straight-sided cells, with stomata (1 – 3) present at the outer side. Dorsal sporophylls ovate-lanceolate, up to 1.2 x 0.5 mm, base obtuse, apex cuspidate, margins short-ciliate-aculeate (cilia up to 0.12 mm long); both ligular and aligular surfaces epidermis with elongate, weakly sinuous to straight-sided cells, stomata sparsely distributed along the midvein at the apical half of the aligular surface epidermis only, SI 3 – 4. Megasporangia deltoid, with similar-sized spores; megaspores 160 - (M 195) - 230 µm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces compactly reticulate. Microsporangia ellipsoid; microspores 30 - (M 35) - 38 µm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces compactly scabrate.

RECOGNITION. This species is distinguished by its deltate, cuspidate, median leaves, occasionally unbranched nature and compactly reticulate megaspores.

DISTRIBUTION. Guinea, Sierra Leone, Nigeria. Type specimen, Welwitsch 45 (B). Cameroon, Central African Republic, DR Congo, Gabon, Angola, Zambia, Mozambique - Tropical regions of Africa.

SPECIMENS EXAMINED. **Sierra Leone**: Kono: Tingi Mt., *Morton & Gledhill* 3151 (K); **Nigeria**: Shabe Rock, *Hambler* 1018 (BM); Ogoja: Ikom, Obokum, *Keay* FHI 28281 (BM); Jos Plateau: Naraguta F. R., *Lawlor & Hall* FHI 46545 (K); **Cameroon**: Bamenda: Bafut, Bafut-Wum Road, Metchen Falls, *Savory* UCI 313 (BM); **Angola**: Golungo Alto: Serra de Alto Queta, *Welwitsch* 45 (holotype, B, BM, K, LISU, P iso.) Lunda: Xa-Sengne, 1200 m, *Exell & Mendoca* 402 (BM); DR Congo: Katanga: Lubumbashi [Elisabethville], *Homble* 194 (BM).

HABITAT. Wet shaded rocks, bare soils, around the bases of boulders in holes in soil, often associated with tiny bryophytes e.g. *Fissidens* spp. (Kornas, 1983); from near sea

level to1200 m.
CONSERVATION STATUS. The species has a wide distribution across the Tropical regions of Africa, with collections of many specimens coming from many different locations.

Selaginella thomensis Alston in Catalogue of the Vascular plants of São Tomé: 97, fig. 3 (1944). Type: Sao Tome. Vanhulst (Macambrara), 1000-1300 m, *A.W. Exell* 423 (BM000785261, holotype; COI00004829, isotype).
Figures 1J, 19.
Plants erect or suberect from a very small creeping base; branch systems 2 – 4 pseudopinnate; rhizophores arising at the axils and/or dorsal side of primary branches and restricted to the basal third of the plant. Leaves anisophyllous, single-veined; stomata 20 – 33 x 17 – 26 µm; ligules up to 0.25 mm long, obturbinate. Lateral leaves asymmetrical, ovate-elliptic to ovate-subovate, up to 3.0 x 1.5 mm, base oblique (obtuse-sub-truncate), apex sub-obtuse to broadly acute, margins serrate-subentire; ligular surface epidermis with isodiametric, sinuous cells, without stomata; aligular surface epidermis with elongate, straight-sided cells on the lamina, less elongate, occasionally isodiametric, sinuous cells on midvein, with sclerotic cells forming patches and bands on lamina, stomata randomly distributed on lamina, margins but concentrated along the midvein,

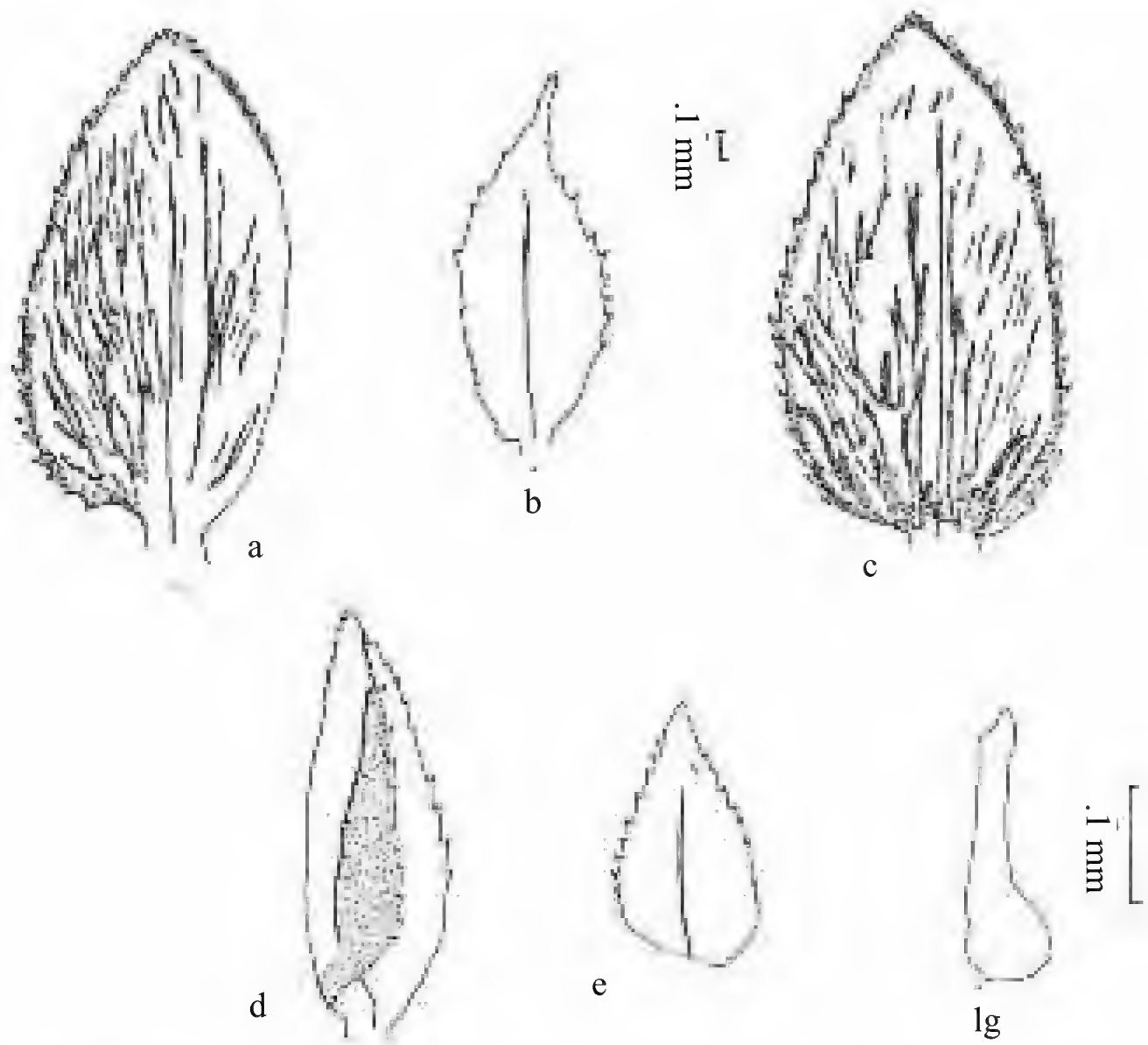

Figure 19. *Selaginella thomensis* Alston, a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg, ligule. All from Exell 423 (BM, holotype).

SI 12 – 14 . Median leaves asymmetrical, oblanceolate, up to 1.3 x 0.7 mm, base oblique, apex cuspidate, margins serrate-aculeate; ligular surface epidermis with elongate, straight-sided cells, without stomata; aligular surface epidermis with isodiametric, weakly sinuous to straight-sided cells, stomata concentrated along the midvein, SI 6 – 7. Axillary leaves symmetrical, ovate, up to 2.8 x 1.6 mm, base obtuse, apex sub-obtuse to broadly acute, margins serrate; ligular surface epidermis with isodiametric, weakly sinuous to straight-sided cells, without stomata; aligular surface epidermis with elongate, straight-sided cells on lamina, less elongate, occasionally isodiametric, weakly sinuous cells on midvein, with sclerotic cells forming patches and bands on lamina, stomata, more or less, evenly distributed on lamina, also on margins, SI 14 – 15. Strobili bilateral, resupinate, at apices of branchlets, up to 5 mm long, with two sporangial arrangements: (a) cone wholly megasporangiate; (b) with dorsal side wholly megasporangiate and ventral side containing both megasporangia and microsporangia randomly arranged. Sporophylls dimorphous. Ventral sporophylls elliptic to elliptic-oblong, up to 2.1 x l.l mm, base obtuse, apex acute, margins sub-entire-aculeate to serrate-subentire, with complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, straight-sided cells, stomata randomly distributed on lamina, SI 11 – 14; aligular surface epidermis with isodiametric, weakly sinuous to straight-sided cells, stomata sparsely distributed on lamina, SI 3 – 4; sporophyll-pteryx with serrate margin, with elongate, straight-sided cells, without stomata. Dorsal sporophylls subtriangular to weakly deltate, up to 1.3 x 0.9 mm, base truncate, apex acuminate, margins serrate-serrulate; both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata randomly distributed on lamina at aligular surface epidermis only, SI 9 – 10. Megasporangia ovoid-triangular to deltoid, with similar-sized spores; megaspores 220 – (M 230) – 245 μm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces compactly reticulate. Microsporangia ellipsoid to spheroid; microspores 20 – (M 26) – 30 μm in equatorial diam., trilete, sub-globose, both proximal and distal surfaces verrucate.
RECOGNITION. *Selaginella thomensis* is very similar to *S. molleri*_from which it is distinguished by its serrate-margined leaves and cuspidate median leaves (*S. molleri* has leaves with short ciliate margins and median leaves with aristate apices).
DISTRIBUTION. Sierra Leone, Togo, Nigeria, Cameroon, Gabon, São Tomé.
SPECIMENS EXAMINED. **Sierra Leone**. York, *Adams* 205 (BM, K). **Nigeria**: Calabar: Kwa Falls, *Richards* 4005 (BM, K); **Cameroon**: Bamenda: *Mile* 43 Mamfe-Bamenda Road, *Richards* 5278 (BM); N'dian: Kameruna, *Dusen Comm* 1895 (BM).
HABITAT. On wet rocks in streams, also on steep rocky banks in forest; up to 2000 m.
CONSERVATION STATUS: Data Deficient (DD). Though this species occurs in six countries, single specimens from four countries were examined during this study. Despite the recent (2016) report of its presence in Togo (Abotsi et al., 2018) and being found in six countries, there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status, hence the DD status accorded this species.

Selaginella versicolor Spring in Bulletin de lAcadémie Royale des Sciences et Belle-Letres de. Bruxelles 10, 1,143 (1843). Type: Senegal : 'Les ravins chez les Landoumas', *J. Heudelot* 704 (G00349406, holotype; B200130255, LG, P00466575, P0046657, isotypes).
Figures 2A, 2B, 20.
S. nitens Baker in Journal of Botany 23: 48 (1885), Fern Allies 99 (1887). Type:

Cameroon, *Kalbreyer* 158 (K).

Plants erect or arching, soboliferous; branch systems 1 - 3 pseudopinnate and/or flabellate with dichotomies; rhizophores restricted to the very base of the plant. Leaves anisophyllous on branches, simple monomorphic on main stem, single-veined; stomata 19 – 29 x13 – 18 µm; ligules up to 0.39 mm long, flabelliform (2 – 4 unicellular acicular cilia at the bases of the ligules of lateral leaves only). Lateral leaves asymmetrical, ovate-oblong, up to 5.0 x 3.0 mm, base oblique, apex acute, margins serrate-sub-entire; ligular surface epidermis with isodiametric, sinuous cells, stomata sparsely distributed near the margins, SI 2 – 3; aligular surface epidermis with elongate, sinuous cells on lamina and more elongate, less sinuous to straight-sided cells on the midvein, with sclerotic cells forming broad bands on lamina running alongside the dvein, stomata randomly distributed on the lamina and the midvein, SI 8 – 10. Median leaves asymmetrical, weakly obovate, up to 2.5 x 1.8 long, base obliquely auriculate, apex aristate (aristae up to same length as lamina), margins denticulate-serrate; ligular surface epidermis with

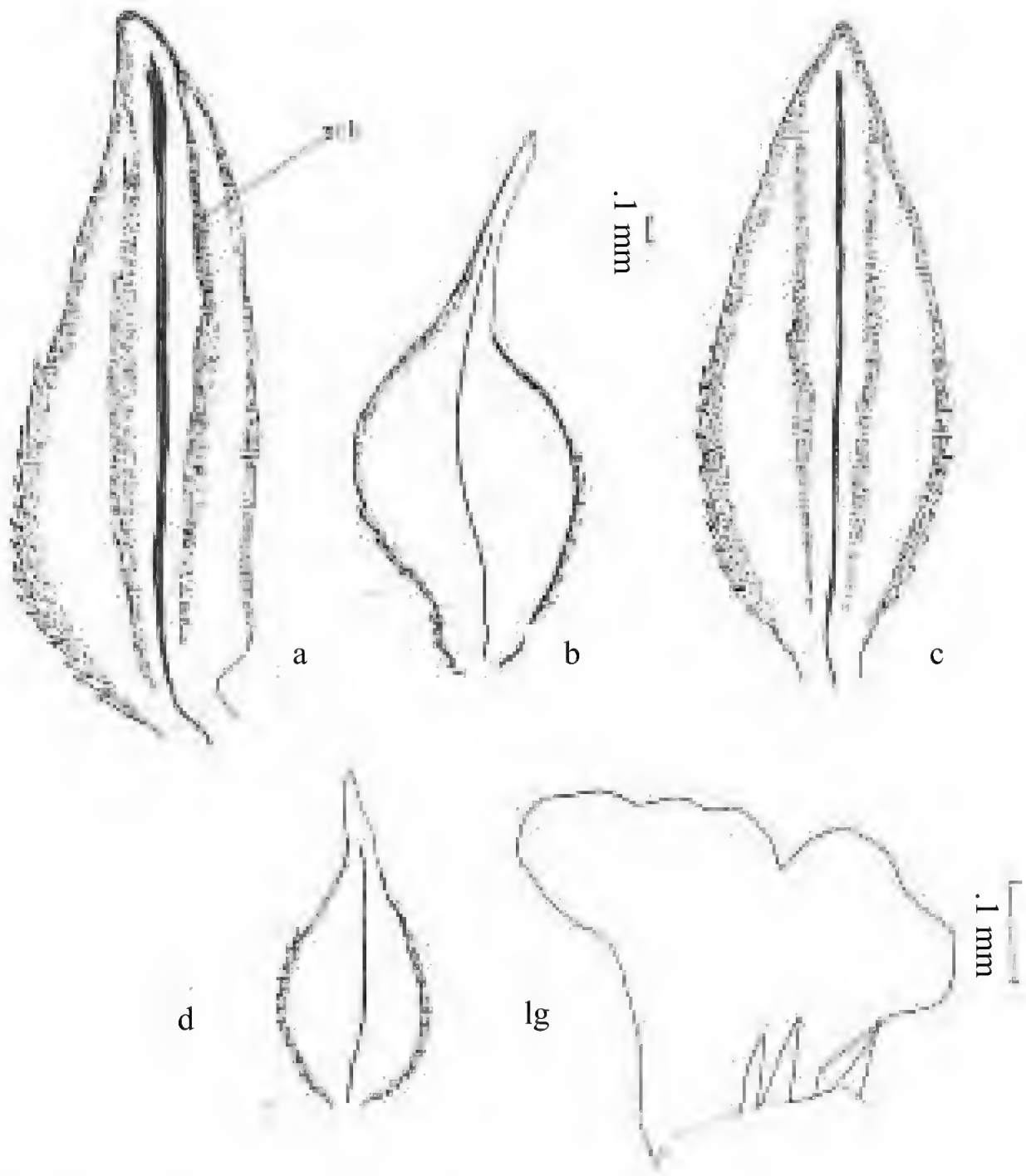

Figure 20. *Selaginella versicolor* Spring., a. lateral leaf (scb bands of sclerotic cells) , b. median leaf, c. axillary leaf, d. sporophyll, lg. ligule. All from Hossain GC 40003 (BM).

elongate, slightly sinuous to straight-sided cells, without stomata; aligular surface epidermis with isodiametric, sinuous cells, stomata randomly distributed on lamina, SI 2 – 3. Axillary leaves symmetrical, ovate, up to 4.7 x 3.2 mm, base sub-attenuate, apex acute, margins of basal half serrate, apical half entire (subentire); ligular surface epidermis with isodiametric, sinuous cells, stomata evenly distributed on lamina, SI 7 – 8; aligular surface epidermis with elongate, occasionally isodiametric, sinuous to straight-sided cells, with sclerotic cells forming two broad bands on lamina running alongside the midvein, stomata randomly distributed on lamina, SI 10 – 12. Strobili tetragonous, at apices of branchlets, with both determinate and intermittent growth patterns, up to 30 mm long, with four sporangial arrangements: (i) cone wholly microsporangiate; (ii) with dorsal side wholly megasporangiate and ventral side wholly microsporangiate; (iii) with dorsal side containing both megasporangia and microsporangia randomly arranged and ventral side wholly microsporangiate; and (iv) with dorsal side containing basal megasporangia and apical microsporangia and ventral side wholly microsporangiate. Sporophylls uniform, keeled, occasionally with sclerotic cells present in bands on lamina, ovate-lanceolate, up to 3.2 x 2.1 mm, base obtuse, apex long cuspidate to aristate (aristae up to 4/5 the length of lamina), margins serrate; both ligular and aligular surface epidermises with elongate, slightly sinuous to straight-sided cells, stomata evenly distributed on lamina of aligular surface epidermis only, SI 7 – 9. Megasporangia triangular-ovoid, with similar-sized spores; megaspores 240 – (M300) – 330 Mm in equatorial diam., with distinct equatorial ring, trilete, sub-globose, proximal surfaces granulose-rugulose, distal surfaces loosely reticulate. Microsporangia ellipsoid; microspores 13 – (M19) – 28 μm in equatorial diam., trilete, globose, both proximal and distal surfaces baculate-verrucate.

RECOGNITION. *Selaginella versicolor* is distinguished from all other West African species by the presence of the two broad sclerotic cells forming bands on the lamina of the lateral and axillary leaves, the 2 – 4 acicular hairs at the bases of the ligules of the lateral leaves and the soboles.

DISTRIBUTION. A tropical African element: Senegal, Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Benin, Nigeria, Cameroon, Equatorial Guinea [Bioko], Gabon, Congo, DR Congo, Angola, Malawi, Uganda, South Sudan.

SPECIMENS EXAMINED. **Senegal**: Coast of Tamara: *Serrand* s.n. (K) ; Ravins chez les Landoumas, *Heudelot* s.n. (isolectotype, LG); **Guinea**: Fouta-Djallon: Dintin (cercle de Mamou), 700 m *Abbayes* 876 (BM); Dalabe: Pitha Ravine, Kola, *Schnell* 7339 (BM, K); **Sierra Leone**: Baiima: *Deighton* 3047 (BM, K); Freetown, Lewis s.n. (BM); Makump: Old Mission House, *Deighton* 1382 (BM); Colony Peninsula: York Pass, 400 m, *Deighton* 3327 (BM, K); loc. cit., *Deighton* 3328 (BM, K); loc. cit., *Deighton* 3329 (BM, K); loc. cit., Bridge on Waterloo-York path, 300 m, *Melville* & *Hooker* 468a (K); Picket Hill, 600 m, *Jones* 325 (BM); loc. cit., 700m, *Jones* 326 (BM); Loma Mt., *Jaeger* 2032, 951 (K); loc. cit., 1300 m, *Jaeger* 1844 (K); Gberia Fotombu, *Small* 418 (K); Between Kanya and Gendema (Bumpe), *Deighton* 6128 (K); Koya, on Bafodia road, 900 m, *Haswell* 66, 77 (K); Sini-Koro, *Jaeger* 1865 (K); Jau (Tunkia), *Deighton* 5223 (K); Gberia, Timbako, *Small* 318 (K); Between Mattru and Gbangbama, *Deighton* 2340 (K); Gola Forest, *Deighton* 459 (K); Giewahun, *Deighton* 460 (K); Kasewe Hills Reserve, 150 m, *Fay* 1082 (NY); 1083 loc. cit., 80m, *Fay* 1066 (NY); No locality, *Deighton* 1382 (K). **Liberia**: Bobei Village: base of Bili Mt., *Winne* 163 (BM); Kitoma, *Harley* F160 (BM); loc. cit., *Harley* F162 (BM); Mt. Bili, *Barker* 1168 (K); loc. cit., *Harley* F197 (BM, K); loc. cit., *Harley* F107 (BM, K); Sanniquellie: Ganta, *Harley* F22

(BM); loc. cit., *Harley* F23 (BM, K); Ganta Mission Hill, *Harley* F231 (BM, K); Webo: Diebla, *Baldwin Jr.* 6287 (BM); Vonjama: Wohmen, *Baldwin Jr.* 10098 (BM, K); Bolahun: Ndange, *Earthy* 21 (BM); Mt Bele road, 500 m, *Adames* 613 (K); LAMCO Headquarters Camp, 550 m, *Adames* 623 (K); **Ivory Coast**: Man: Bepleu, Mt. Tonkoui, 400 m, *Abbayes* 294 (BM); loc. cit., 1050 m, *Abbayes* 224 (BM); loc. cit., *Abbayes* 225 (BM); loc. cit., 110 m, *Abbayes* 577 (BM); Tai and Guiglo, *Abbayes* 2061 (BM); **Ghana**: Kibi: Puso Puso Ravine, 400 m, *Adams* 89 (BM); loc. cit., *Adams* 72 (BM); loc. cit., 500 m, Box 3257 (BM); loc. cit., *Adams* 409 (K); loc. cit., *Bigger* 414 (K); Begoro: Akrum Waterfall, 500 m, Box 2949 (BM); loc. cit., *Bigger* 2489 (K); S. Scarp F. R., *Bigger* 2481 (K); Bunso, *Thompson* s.n. (BM); Achimota, *Foote* 48 (BM); Mampong Scarp: Ninting Hill, 500 m, Box 2904 (BM); Asiakwa, 300-400 m, *Adams* 191 (BM); Mpraeso Scarp, Hall 2639 (BM); loc. cit., *Hall* 0140 (K); Atewa Range F.R., 800 m, *Hossain* GC40003 (BM, K); loc. cit., 500 m, *Bigger* 2409 (K); loc. cit., 700 m, *Bigger* 2509 (K); loc. cit., *Enti & Bowling* GC37416 (K); Obomen: S. Scarp F. R., *Obeng-Darko* 5090 (K); Winneba, 60 m, Vigne 2915 (K); Kibi-Akim, *Johnson* 248, 259 (K); **Togo**: Tomegbe: Badou, *Mathey & Scholz* 279 (K).; **Nigeria**: Calabar: mile 58, Calabar-Mamfe road, *Baldwin Jr.* 13765 (BM); loc. cit., mile 54, *Baldwin Jr.* 13759 (BM) ; Ogoja: Ikom, Obokum, *Keay* FHI 28283 (BM); Aboabam, *Keay* FHI 28231 (BM); Oyo: Busogboro, Ibadan North F. R., Keay FHI 25358 (BM); Ile Ife, University of Ife Campus, Hall 15 (K); Jamaa: Dogon Kurmi, *Mutch & Latilo* FHI 19949 (BM); loc. cit., Sanga River F. R., *Keay* FHI 22254 109 (BM); loc. cit., 300 m, *Killick* 40 (K); loc. cit., near Jagindi, *Hepper* 1035 (K); Ondo: Akure, Idanre, 200 m, *Savory* UCI 38 (BM); loc. cit., *Richards* 3823 (BM, K); loc. cit., *Keay* FHI 22670 (BM); loc. cit., *Brenan* 3852 (K); loc. cit., *Keay* FHI 25498 (BM); Benin: Ehor and Ibekwe areas, c 100 m, *Fairbairn* 19 (BM); Bamenda: Bafut, *Savory* UCI (BM); Wum Escarpment, 900 m, *Savory* UCI 351 (BM); Ibadan: Gambari F.R., *Onochie* FHI 34991 (K); loc. cit., *Onochie* FHI 35318 (K); Qwari: N.A. Gawu Hills, *Onochie* FHI 35915 (K); Okelife, 400 m, *Onochie* FHI 34347 (K); Abuja Emirate: Gurara Falls, *Tuley* 1672 (K); Kagoro-Jemaa Road F. R., *Tuley* 1781 (K); Ilesha: Erin-Ijesha, *Gbile & Daramola* FHI 675% (K); **Cameroon**: Mupanga, c 1000-1100 m, *Kalbreyer* 152 (BM); Kumba: mile 52 on Victoria-Kumba road, *Brenan* 4068 (BM, K); loc. cit., bank of river Kumba from the Barombi Crater Lake, 350 m, *Leeuwenberg* 6878 (K); Mamfe, c 250 m, *Rosevear* s.n. (BM) ; mile 40 on Mamfe-Bamenda road, *Baldwin Jr.* 13819 (BM); Buea, 1000 m, *Rosevear* 38 (BM); loc. cit., *Rosevear* 40 (BM); loc. cit., *Tryon & Tryon* 6531 (K); loc. cit., *Gregory* 90 (K); Urwaldgebiet: Station Johann-Albrechtshohe, *Staudt* 515 (BM, K); loc. cit., *Staudt* 468 (K); Lino: bank of Ntotse river, *Dunlap* 256 (K); No localities: *Grenss* 578 (BM), *Kalbreyer* 158 (K); **Equatorial Guinea**: Bioko: *Moka*, c 1400 m, *Melville* 462 (BM); loc. cit., *Exell* 794 (BM); loc. cit., *Ureka*, c 200 m, on cocoa trees, *Thorold* TF 33 (BM); No locality, *Mann* 149 (K). **DR Congo:** near Kamuhene river, 950 m, *Osmaston* 2243 (BM); **South Sudan**: Aloma Plateau: Yei, Kajiko River, c 1200 m, *Macleay*. 475 (BM); **Uganda**: Budongo, *Eggeling* 2107 (BM).

HABITAT. On wet rocks near waterfalls, on grounds and rocks in shady moist forest, also on stream banks in plantations, sometimes (but rarely) epiphytic on tree trunks; sea level to 1700 m.

CONSERVATION STATUS: Least Concern (LC). The species has a very large distribution, with many specimens from many different locations across the continent, including recent collections (Abotsi et al., 2018).

Selaginella vogelii Spring in Mémoires de l'Académie Royale des Sciences, Lettres et Beaux Arts de Belgique 24: 170, 171 (1850). Type: 'Hab. In insula Fernado-Po, fr. Nov.' *S. Vogel* s.n. (K000351227 holotype; P00466572, isotype).
Figure 21.
S. africana A. Br. (1857) Index Sem. Berol. Type: Cult. in Hort. Berol., believed to be from Africa *sine coll. s.n.* (B, holotype).
S. dinklageana Sadeb. in Jahrb. Hamb. Wiss. Anst. 14, Suppl. 16 (1897). Type: Cameroons, Dinklage 241. (HBG, holotype).
Plants erect, stout from a creeping rhizome; branch-systems 3 – 4 pseudopinnate, flabellate with few dichotomies, pubescent at dorsal side; rhizophores restricted to the very base of the plant. Leaves anisophyllous on branches, simple monomorphic on main stem, single-veined; stomata 24 – 31 x 20 – 23 μm; ligules up to 0.25 mm long, obturbinate. Lateral leaves asymmetrical, lanceolate-oblong, up to 3.5 x 1.5 mm, base oblique, apex acute, margins entire to sub-entire; ligular surface epidermis with

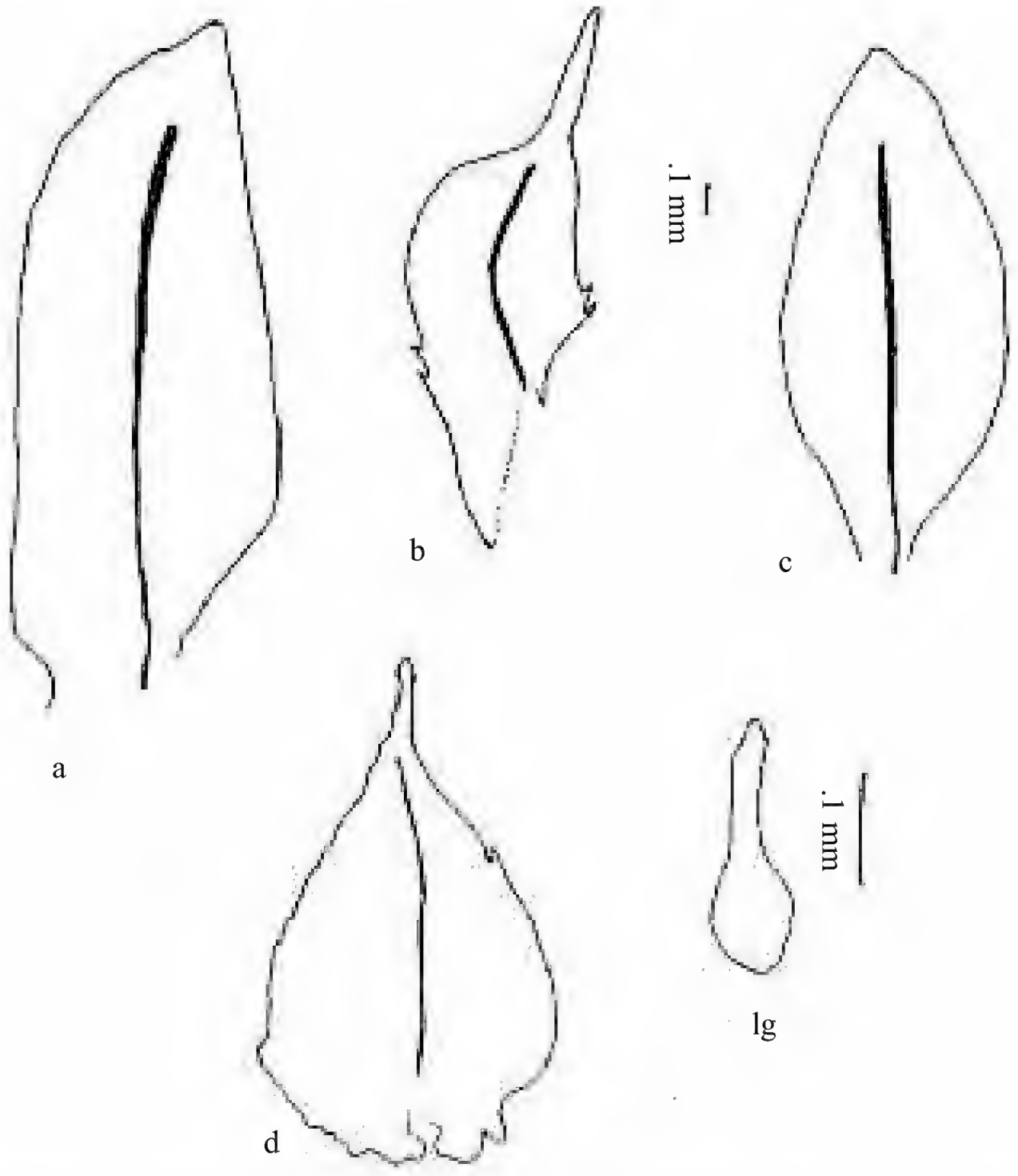

Figure 21. *Selaginella vogelii* Spring, a. lateral leaf, b. median leaf, c. axillary leaf, d. sporophyll, lg. ligule. All from Box 3589 (BM).

isodiametric, undulating to sinuous cells, without stomata; aligular surface epidermis with elongate, undulating, sinuous cells, stomata randomly distributed on lamina, SI 12 – 14. Median leaves asymmetrical, sub-obovate, up to 1.2 x 0.7 mm, base oblique (decurrent), apex caudate, margins entire-subentire (distantly serrate); ligular surface epidermis with elongate, sinuous cells, without stomata; aligular surface epidermis with isodiametric, sinuous cells, stomata sparsely distributed on lamina and towards the margins, SI 3 – (M 4) – 4. Axillary leaves symmetrical, obovate to oblanceolate, up to 3.0 x 1.6 mm, base sub-attenuate, apex acute, margins entire (sub-entire); ligular surface epidermis with isodiametric, sinuous to undulating cells, stomata randomly distributed on the lamina, SI 7 – 9; aligular surface epidermis with elongate, undulating, sinuous cells, stomata randomly distributed on the lamina, SI 11 – 13. Strobili tetragonous, at apices of branchlets, up to 10 mm long, with three sporangial arrangements: (a) cone wholly microsporangiate; (b) with basal megasporangiate zone and apical microsporangiate zone; (c) with dorsal side containing both megasporangia and microsporangia randomly arranged and ventral side wholly microsporangiate. Sporophylls uniform (subuniform) keeled, broadly ovate to widely trullate, up to 1.5 x 0.8 mm, base obtuse to sub-auriculate, apex cuspidate, margins sub-entire (distantly serrate); both ligular and aligular surfaces epidermis with elongate, undulating, sinuous cells, stomata sparsely distributed on lamina of aligular surface epidermis only, SI 5 – 7. Megasporangia deltoid, with 81% similar-sized and 19% 2L: 2S spores; megaspores 210 – (M 285) – 328 μm in widest area, trilete, tetrahedral-sub-triangular, both proximal and distal surfaces baculate. Microsporangia ellipsoid; microspores 25 – (M 30) – 40 μm in equatorial diam., trilete, globose, both proximal and distal surfaces verrucate-echinate.

RECOGNITION. *Selaginella vogelii* is distinguished from all the other West African species by its pubescent stems and branches.

DISTRIBUTION. Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Benin, Nigeria, Cameroon, Equatorial Guinea (Bioko), Gabon, Congo, DR Congo, Angola, Tanzania, Kenya, Zambia.

SPECIMENS EXAMINED. **Guinea**: Nzo: *Schnell* 583 (BM); loc. cit., *Abbayes* 598 (BM); Kakoulima: *Nickles* s .n. (K) ; **Sierra Leone**: N. Kono: Tingi Mts., 600 m, *Morton & Gledhill* 1985 (K); loc. cit., *Fisher* 89 (K); Yifin, foot of Loma Mt., *Morton & Gledhill* 1136 (K); Gola North: Garua, *Bakshi* 38 (K); loc. cit., Forest Block III, *Small* 532 (K); Jau (Tunkia), *Deighton* 5222 (K) ; Benikoro, 300 m, *Thomas* 2948 (K); Giewahun, *Deighton* 457 (K); Kofiu Mt., *Scott-Elliot* 4614 (K); Maraka, *Morton & Jarr* 1297 (K).; **Liberia**: Kitoma, *Harley* F160a (BM, K); Bobei, *Harley* F232 (BM, K); Ganta, *Harley* F22, F22A (K); Webo: Mnanulu, *Baldwin Jr.* 6059 (BM, K); Sanniquellie: Sakimpa, foot of Bilimu, *Harley* F115 (BM, K); Since Basin, *Whyte* s.n. (K); Gangi, Linder 850 (K); Boporo: Zuie, *Baldwin Jr.* 12090 (BM); **Ivory Coast**: Tai, Guiglo, *Abbayes* 2060 (BM) ; Niapidou: 64 km N of Sassandra, *Leeuwenberg* 1717 Bipindi (K); **Ghana**: Nfuom: Kakum F.R., c 200 m, Box 2861 (BM); Kibi: Puso Puso Ravine, c 300-500 m, Box 3258 (BM); Fanti-Nyankumasi, Box 2073 (BM); Potroasi, *Adams* 165 (BM); Banka, Ashanti, *Irvine* 480 (K); Akim: Kibi Hills, *Johnston* 264 (K); Akwapim Hills, *Johnston* 380 (K); Akropong Mts., *Brown* 332 (K); Kwadjo Nkwanta to Sikamang, *Kitson* 1246 (K); Tarkwa: Neung F. R., Agona, *Cudjoe* 18 (K); Konongo, *Akpabla* 254 (K) ; Anyinam, *Obeng & Dade* MDA 4 (K). NIGERIA. Calabar, *Robb* s.n. (BM); loc. cit., Abak, Jackson's Land, *Maggs* 151 (BM, K); mile 54, Calabar-Mamfe road, *Baldwin Jr.* 13760 (BM); Kwa Falls, *Richards* 3995 (BM, K); loc. cit., *Richards* 3991 (BM, K); Benin: Ehor and Tbekwe, c 100 m, *Fairbairn* 16 (BM); Sonkwala: Ijua, 900 m, *Savory & Keay* FHI

25028 (BM); Okomu F.R., Compartment 53, *Richards* 3857 (BM, K); loc. cit., Compartment 56, *Brenan* 3635 (BM, K); Nsuka, *Chaloner* 15/1 (K); Boje: Aboabam, *Jones* & Onochie 18628 (BM, K); Cgoja: Abbot Village, Jones 1474 (BM); Oban, *Richards* 5144 (BM); Osomba Village, *Onyeachusin* & *Latilo* FHI 48194 (K); Owenna: Akue F.R., *Onochie* FHI 34218 (K); **Cameroon**: Buea, c 1000 m, *Tryon* & *Tryon* 6484 (K); Man Spring, Mt. Cameroon, *Hambler* 162 (BM); loc. cit., c 1000 m, *Fraser* 31 (BM); loc. cit., 1200 m, *Migeod* 12 (BM, K); loc. cit., 300 m, *Dunlap* 239 (K); loc. cit., *Dunlap* 132 (K); loc. cit., *Maitland* 838 (K); Victoria, *Brenan* 4384 (BM, K); Between Victoria and Kumba, *Hutchinson* & *Metcalfe* 140 (K); Kunba: Lake Barombi, 350 m, *Leeuwenberg* 6852 (K); loc. cit., Box 3598 (BM); Urwaldgebiet: Bipinde, *Zenker* 903 (BM); loc. cit., *Zenker* 4454 (BM); Barombi Station, *Preuss* 279 (BM); Yaounde Station, 800 m, *Zenker* & *Staudt* 35 (BM); loc. cit., *Zenker* & *Staudt* 179 (BM); loc. cit., *Zenker* & *Staudt* 190 (BM); Mapanga, c 700-1300 m, *Kalbreyer* 150 (BM); Mamfe-Assam forest, 300 m, Gregory 253 (K); **Equatoria Guinea**. Bioko: Mt. Balea, *Guinea* 359 (BM); loc. cit., *Mann* 149 (BM, K); No localities: *Barter* 1044, 1398 (K); *Mann* 1406 (K); *Vogel* s.n. (K).

HABITAT. On rocks or ground in wet forest especially near water; sea level to 1800 m.

CONSERVATION STATUS: Least Concern (LC). The species is widely distributed with many specimens collected from many locations across the continent, including recent collections (Abotsi et al., 2018).

Selaginella zechii Hieron. in Die natürlicheb. Pflanzenfamilien 1, 4: 697 (1901). Type: Togo: near Kete Kratschi, 1900, *Count Zech* 388 (B200154191, holotype).

Figures: 2G, 22.

Plants erect or sub-erect, main stem branched at the base; branch-system 1-3 pseudopinnate; rhizophores arising at the axils of primary branches and restricted to the basal quarter of the plant. Leaves anisophyllous, single-veined; stomata 33 – 38 x 19 – 23 µm; ligules up to 0.29 mm long, obclavate. Lateral leaves asymmetrical, ovate-oblong to deltate, up to 2. 6 x 1.5 mm, base sub-obtuse to oblique, apex acute to sub-obtuse, margins of basal half long-ciliate-subentire (cilia up to 0.32 mm long), apical half serrate; ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, occasionally isodiametric, sinuous to straight-sided cells, with sclerotic cells forming patches on lamina, stomata randomly distributed on lamina, midvein and margins, SI 13 – (M 15) – 16. Median leaves asymmetrical, sub-oblanceolate, up to 1.6 x 0.6 mm, base obtuse, apex aristate (aristae up to same length as lamina), margins ciliate-serrate (cilia up to 0.20 mm long); ligular surface epidermis with elongate, sinuous cells, without stomata; aligular surface epidermis with isodiametric, sinuous to straight-sided cells, stomata concentrated along the midvein, SI 4 – (M 5) – 5. Axillary leaves symmetrical, ovate-deltate, up to 2.5 x 1.4 mm, base weakly obtuse to subcordate, apex acute to apiculate, margins long-ciliate-serrate (cilia up to 0.36 mm long); ligular surface epidermis with isodiametric, polygonal, straight-sided cells, without stomata; aligular surface epidermis with elongate, occasionally isodiametric, sinuous to straight-sided cells, with sclerotic cells forming patches on lamina, stomata randomly distributed on lamina, mid vein and margins, SI 12 – (M 13) – 14. Strobili bilateral, resupinate, at apices of branchlets, up to 12 mm long, with two sporangial arrangements: (a) cone wholly megasporangiate; (b) with dorsal side wholly megasporangiate and ventral side containing both megasporangia and microsporangia randomly arranged. Sporophylls dimorphous. Ventral sporophylls

oblong-ovate, up to 2.1 x 0.9 mm, base obtuse, apex apiculate, margins of basal half short-ciliate-sub-entire (cilia up to 0.16 mm long), apical half distantly serrate-denticulate, with a complete sporophyll-pteryx at the adaxial surface; ligular surface epidermis with elongate, sinuous cells, stomata randomly distributed on lamina at side with sporophyll-pteryx, SI 14 –16; aligular surface epidermis with isodiametric, polygonal, straight-sided cells, stomata sparsely distributed on lamina and margins, SI 3 – 5; sporophyll-pteryx with ciliate margin (cilia up to 0.18 mm long), with elongate, sinuous cells, stomata occasionally present on the outer side. Dorsal sporophylls

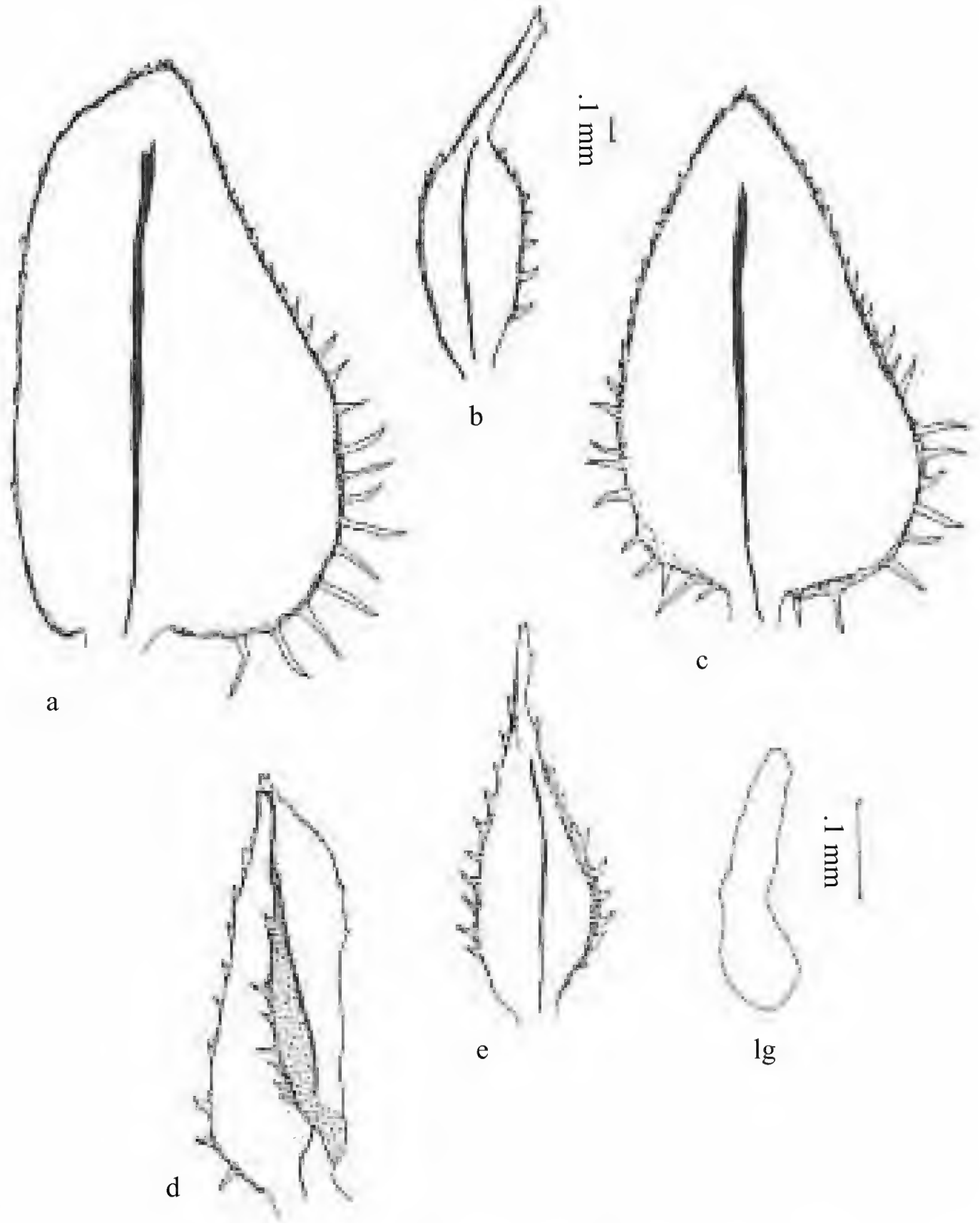

Figure 22. *Selaginella zechii* Hieron., a. lateral leaf, b. median leaf, c. axillary leaf, d. ventral sporophyll, e. dorsal sporophyll, lg. ligule. All from Box 3506 (BM).

lanceolate, up to 1.7 x 0.6 mm, base obtuse, apex cuspidate to aristate (aristae up to two-thirds the length of lamina); both ligular and aligular surfaces epidermis with elongate, straight-sided cells, stomata sparsely distributed along midvein at aligular surface epidermis only, SI 2 – 3. Megasporangia ovoid to deltoid, with 97% similar-sized and 3% 3L:1S spores; megaspores 160 – (M 180) – 215 µm in equatorial diam., trilete, subglobose, proximal surface occasionally with 3 scars (one scar in each area defined by triradiate marks), both proximal and distal granulose to minutely rugulose Microsporangia ellipsoid to roundish; microspores 20 – (M 23) – 26 µm in widest area, trilete, tetrahedral-subtriangular, both proximal and distal surfaces finely granulose.

RECOGNITION. This species is distinguished by its long, ciliate leaves and the suboblanceolate median leaves.

DISTRIBUTION. Guinea, Ghana, Togo, Nigeria.

SPECIMENS EXAMINED. **Guinea**: Boule Col.: Macenta, *Schnell* 125 (BM); **Ghana**: Kibi, c 350 m, Box 3506 (BM); **Togo**: Kete Krachi, *Zech* 388 (Type, B); **Nigeria**: Silang above Gurum, 1160 m, *Hepper* 1333 (K).

HABITAT. On wet rocks and moist lateritic banks in forest; up to 1160m.

CONSERVATION STATUS: Data Deficient (DD). The species is known to occur in four countries with single specimens from each of the countries examined during this study. The latest collection data are from 1974 (Abotsi et al., 2018).

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PIRIN QUILLWORT, *ISOETES PIRINICA* SP. NOV. (ISOETACEAE), A NEW ENDEMIC LYCOPHYTE FROM BULGARIA

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KEY WORDS: *Isoetes pirinica, I. lacustris*, *I. creussensis*, Bulgaria

ABSTRACT

Isoetes pirinica sp. nov. is an endemic lycophyte of the eastern Balkan Region, found only in the Pirin Mountains of southwestern Bulgaria. It is the fourth decaploid (10×) species of the genus to be recognized globally. It has uniquely small spores for an *Isoetes* of such a ploidy level and commonly exhibits an exceptionally echinate-like megaspore ornamentation for a member of the *I. lacustris* complex. The species is one of many endemic vascular plants of the Pirin Mountains and is believed to be of recent (<12,000 years BP) origin. While geographically restricted, *I. pirinica* is locally abundant and at least for the foreseeable future, appears to have a secure and self-sustaining population.

INTRODUCTION

Although quillworts (*Isoetes*; Isoetaceae) constitute a diverse cosmopolitan lycopod genus of over 200 species (Troia et al., 2016; Brunton & Troia, 2018), only *I. lacustris* L. is known from the eastern Balkan Region of Europe (Stefanova & Ivanova, 2000). Field examination of several populations in the Pirin Mountains of southwestern Bulgaria in 1998 convinced eminent British pteridologist A.C. Jermy that these plants represented "something entirely new but not [*I.*] *echinospora* [M. Durieu]" (pers. comm., September 1998). Jermy's interpretation was likely influenced by the substantial distance between these occurrences and the contiguous range of *I. lacustris* in northern Europe, and by the high incidence of endemism known from the Pirin Mountains (Dimitrova, 2004; Petrova & Vladimirov, 2010). This area also is only 400 km south of the comparably highland Carpathian region in southern Romania that is recognized as a globally significant centre of endemism (Hurdu et al., 2012).

Cytological investigations by D.M. Britton of the 1998 Jermy et al. material determined this Pirin Mountains *Isoetes* be decaploid (2n=10×=110) (D.M. Britton, pers. comm., 1998), as with *I. lacustris* (s.s.) elsewhere in Europe (Grigoryan et al., 2021). The distinctive megaspore ornamentation characteristics noted by Jermy (pers. comm., 1998) were confirmed in Scanning Electron Microscope (SEM) images taken by Britton. It was unclear then, however, if these (and some microspore distinctions) represented only a locally significant disjunct variant within *I. lacustris* (s.l.) or constituted a genetically distinct and taxonomically significant entity. Investigations went no further at that time.

Taxonomic boundaries within *Isoetes* are being actively reassessed by contemporary

molecular studies that imply the existence of many cryptic entities (Schafran et al., 2018) and suggest that many *Isoetes* taxa have evolved relatively recently (Wood et al., 2020). Molecular evidence also suggests that the *I. lacustris* complex is of North American origin (Grigoryan et al., 2021), also implying that diversification in Europe would likely have occurred recently.

Expanding upon the investigations of Jermy and Britton in the late 1990s and employing new understanding arising from recent research on *Isoetes lacustris* (s.l.), has enabled the development of greater taxonomic clarity both of the complex in general and the Pirin Mountains populations in particular. The present study provides evidence in support of Jermy's initial conclusion that these populations constitute a distinct, previously undescribed species.

FIGURE 1. *Isoetes lacustris* complex taxa in Europe and its Bulgarian habitat. (A) Distribution of *Isoetes lacustris* (s.l.) in Europe; *I. lacustris* (s.s.) range continuously shaded (adapted from Brunton et al., 2020); (B) A.C. Jermy collecting *Isoetes* in Lake Ribno Banderishko, 2200 m asl, Pirin Mountains, Bulgaria (Photo: P. Acock, 28 August 1998); (C) Lake Bezbog, 2248 m asl, a typical subalpine Pirin National Park *Isoetes* site (Photo: D. Ivanova, 15 August 2006)

METHODS

Vouchers of the Pirin Mountains *Isoetes* collected by A.C. Jermy, D. Ivanova and P. Acock were examined both as live plants and dried herbarium specimens. SEM images of megaspores and microspores from the Jermy plants and from specimens of associated taxa were prepared by D.M. Britton at the University of Guelph, Canada in 1998 and 1999 following the technique described in Brunton & Britton (2006). Additional SEM images were produced at the Canadian Museum of Nature during the present study. These latter samples of air-dried spores were attached to SEM stubs by means of adhesive carbon discs. These were sputter coated with a gold / palladium alloy (Au/Pd) and examined with a 2017 model FEI Apreo SEM (at 15 kV and 25 pA, with a working distance of 10 mm and a spot size of 6).

Cytological determinations were made by D.M. Britton from live material of *A.C. Jermy, D. Ivanova & P. Acock 22,838* (Lake Muratovo), *A.C. Jermy, D. Ivanova & P. Acock 22,839* (Lake Ribno Banderishko), *A.C. Jermy, D. Ivanova & P. Acock 22,847* (Lake Dolno Kremensko), and *A.C. Jermy, D. Ivanova & P. Acock 22,850* (Lake Popovo). Plants from those sampled populations were grown in distilled water in a growth chamber. The developing root tips were excised and pre-treated in aqueous paradichlorobenzene (PDB) at room temperature for four hours. They were then washed in distilled water, fixed in acetic alcohol (3:1 absolute ethyl alcohol to glacial acetic acid) for 30 minutes or more, hydrolysed in Warmke's solution (1:1 concentrated HCl to absolute ethyl alcohol) for 7-10 minutes at room temperature, and stained in leucobasic fuchsin (Feulgen) for two hours. The meristems were squashed under a cover glass in 45% acetocarmine stain and examined.

Optical inspection and identification of *Isoetes* plants preserved in BM, DFB, MICH, OAC, P, PH and SOM (herbarium codes of Thiers (2021)) enabled comparisons of megaspore and microspore size as well as ornamentation features and patterns in these plants with other European specimens within the *I. lacustris* complex. These characteristics were also compared to morphological data documented in pertinent literature including Pfeiffer (1922), Berthet & Lecocq (1977), Brunton et al. (2020) and Grigoryan et al. (2021).

Contemporary examination of megaspores and microspores was undertaken with the aid of a Leica Wild M3B dissecting microscope at 40× magnification. Spore measurements and leaf width (at mid-point) were determined with the aid of an in-mount graticule (ocular micrometer). Megaspore size represents the average width across the equatorial region of at least 20 spores. Comparable microspore measurements are based on a minimum of 20 longitudinal measurements taken from SEM images of clusters of spores. Care was taken not to include measurements of microspores positioned on end on the SEM stubs, which provides an inaccurate representation of total length.

RESULTS AND DISCUSSION

The Pirin Mountains *Isoetes* is far disjunct from the continuous range of *I. lacustris* across northern and western Europe (Figure 1A) (Stefanova & Ivanova, 2004; Grigoryan et al., 2021). Its narrowly restricted distribution is reminiscent of that of *I. creussensis* J.J. Lazare and S. Riba, a species formerly submerged within *I. lacustris* (s.l.) (Lazare & Riba, 2010; Brunton et al., 2020). Both of these are subalpine-alpine taxa, the Pirin Mountain *Isoetes* occurring at a slightly greater average elevation (2050-2550 m asl) and thus constituting the highest elevation *Isoetes* known in Europe. This *Isoetes* is typically found in non-calcareous substrate in the shallow to deep oligotrophic to mesotrophic

water of small, subalpine-alpine glacial lakes in the Northern Pirin Mountains (Figure 1B and C). The lakes are situated singly or in groups of up to 11 in cirques or glacier troughs over granitic substrate; banks and bottoms are covered by stony morainic material. The water of these lakes is cold and very transparent (clear to 10-15 m depth), with high oxygen saturation, low mineralization, very low concentration of hydrocarbonates (Dimitrova, 2004) and a low amount of organic substances (D. Ivanova, pers. obs.). Some lakes exhibit advanced stages of lake succession and represent macrophyte and peat-bog types (Dimitrova, 2004). *Isoetes* occurs in the more or less shallow (from a few centimetres to a few metres) peripheral parts of the lakes, forming monodominant communities or sometimes growing with a small number of associated vascular plants. The most common associates are *Sparganium angustifolium* Michx., *Ranunculus aquatilis* L. and rarely, *Subularia aquatica* L.

The general form of the plants, their spore morphology and their cytology combine to identify the Pirin Mountains population as being within the *Isoetes lacustris* complex. On average, these constitute the smallest aquatic *Isoetes* plants in Europe, their mostly upright leaves typically reaching 6-7 cm in length (Figure 2A). Plants in sites with particularly favourable conditions can grow significantly taller, however, with individuals 12-14 cm long observed in Lake Popovo in 1989 (D. Ivanova, pers. obs.). Occurrences

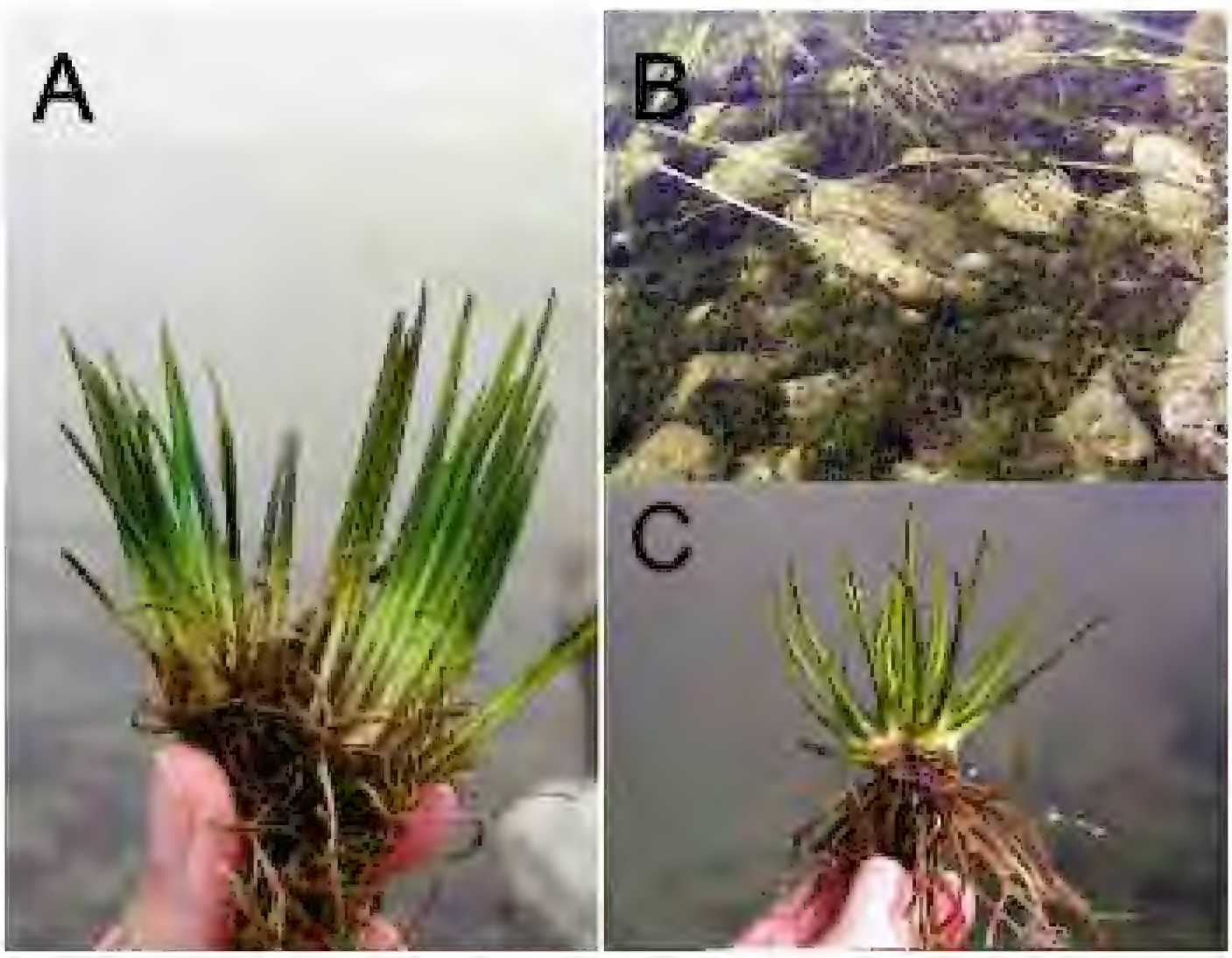

FIGURE 2. *Isoetes pirinica* plants. (A) several densely grown plants with erect-ascending leaves, Lake Dolno Kremensko, 10 September 2006; (B) dense growth ('lawn') of *Isoetes* in shallow water growing with *Sparganium angustifolium* along shore of Lake Bezbog, 15 August 2006; (C) open-grown plant with widely spread leaves from swollen bases, in one of the Popovi group of lakes, 10 September 2006 (Photos: D. Ivanova)

are often densely packed, forming submerged 'lawns' consisting of thousands of individuals (Figure 2B). The swollen, plump leaf bases of more open grown plants not restrained within dense 'lawns' appear to force the otherwise stiff, narrow leaves to spread outwardly (Figure 2C) more conspicuously than most other Northern Hemisphere aquatic *Isoetes* (D.F. Brunton, pers. obs.).

Velum coverage of the sporangia of Prin Mountains *Isoetes* examined here varies from 30-50%, which is consistent with other taxa within the *I. lacustris* complex (Brunton et al., 2020; Grigoryan et al., 2021; D.F. Brunton, pers. obs.).

Cytology

Cytological studies in 1998 by D.M. Britton determined that populations from four different lakes in Pirin National Park were decaploid (2n=10×=110) (Figure 3). Aquatic *Isoetes lacustris* (s.s.) and terrestrial *I. durieui* Bory are the only other known European decaploids (Troia, 2001; Troia et al., 2016). Pyrenean endemic *I. creussensis* is considered to be dodecaploid (2n=12×=132) (Lazare & Riba, 2010; Brunton et al., 2020).

Spore Morphology

The spores of the Pirin Mountains *Isoetes* demonstrate several distinctive characteristics (Figure 4). Most notably, both the megaspores and microspores are uniquely small for

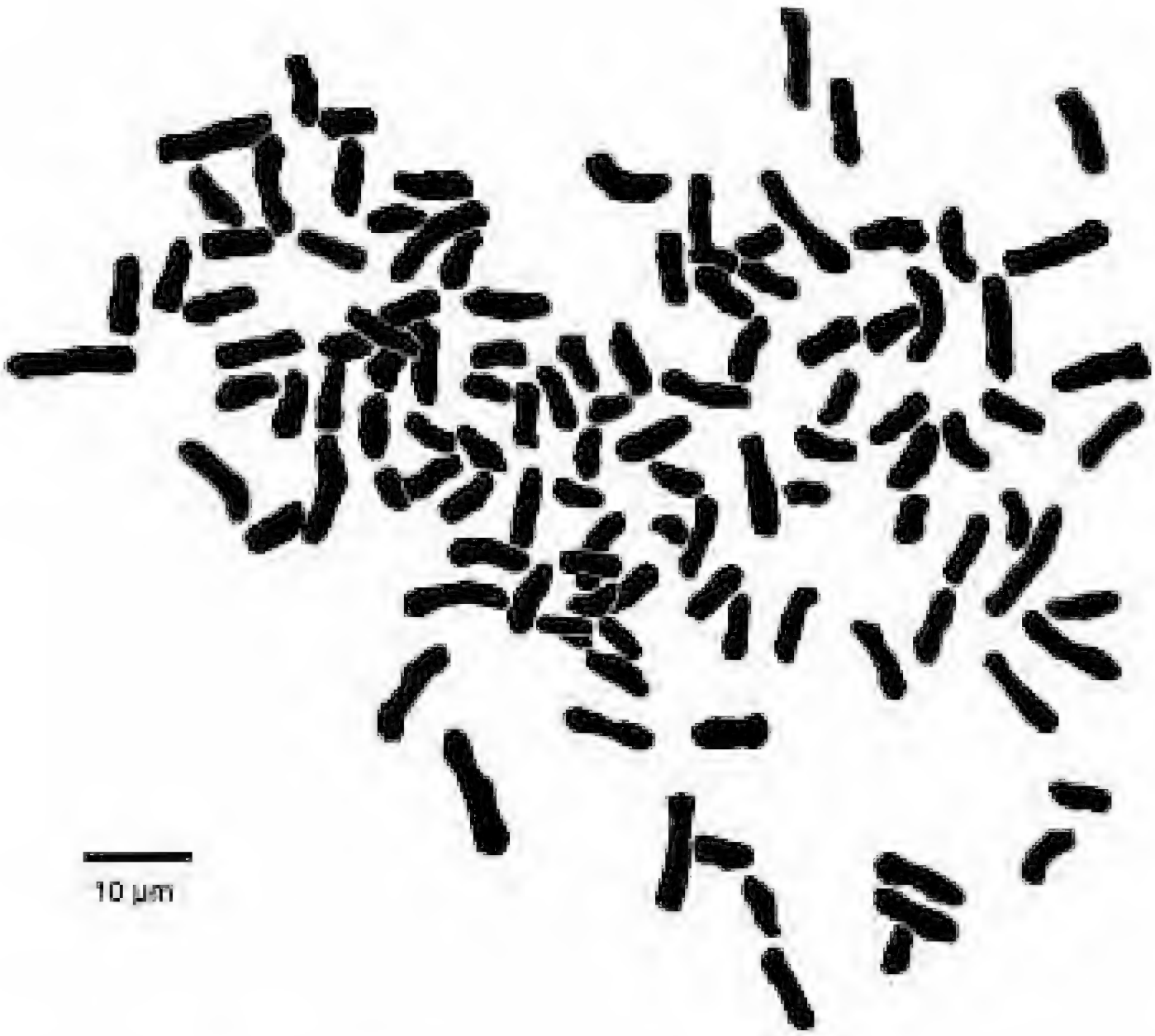

FIGURE 3. Interpretive sketch of 2n=10×=110 chromosome squash showing root tip mitosis in *Isoetes pirinica* (Lake Dolno Kremensko, Pirin National Park, Bulgaria, *Jermy, Ivanova & Acock 22,847*, 29 August 1998, SOM, DFB)

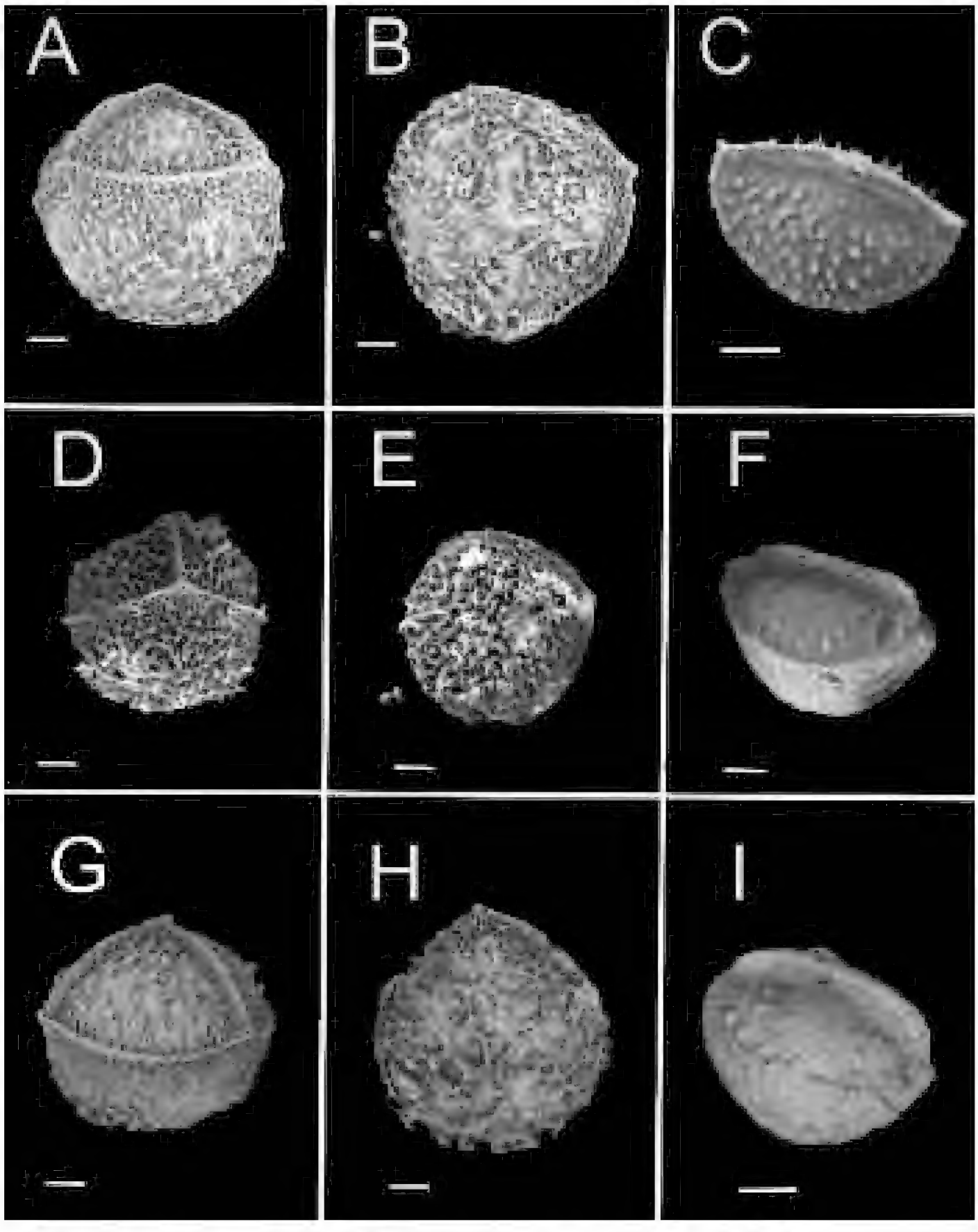

FIGURE 4: Comparative features of European *Isoetes lacustris* (s.l.) spores. A-C: *I. lacustris* (s.s.), D-F: *I. pirinica*, G-I: *I. creussensis*; (A, D, G) megaspore lateral view; (B, E, H) megaspore distal view; (C, F, I) microspores; (A) *Lohammer s.n.,* 1971, Härjedalen, Sweden, P00783450; (B) *Voges s.n.*, 1998, Lake Almindsø, Denmark, DFB; (C) *Billot s.n.*, 1861, Lac de Gérardmer, France, P01246734; (D and E) *Jermy, Ivanova & Acock 22,847*, 29 August 1998, Lake Dolno Kremensko, Pirin National Park, Bulgaria, DFB; (F) *Jermy, Ivanova & Acock 22,838*, 28 August 1998, Lake Muratovo, Pirin National Park, Bulgaria, DFB; (G) *Brunton & McIntosh 19,938*, 2017, Estany de la Pradella, France, DFB; (H and I) *Brunton & McIntosh 19,928*, 2017, El Serrat, Andorra, DFB. Megaspore scale bar = 100 µm, microspore scale bar = 10 µm (SEM images: P.C. Sokoloff & D.F. Brunton, CMN, 2017-2020)

an *Isoetes* of such a high ploidy level (Figures 4D-F). Spore size – especially microspore size – is usually a reliable indicator of ploidy levels amongst *Isoetes* populations in at least the Northern Hemisphere (Kott & Britton, 1983; Troia, 2001). The megaspores of cytologically confirmed 10× Pirin Mountains *Isoetes*, however, average 516.5 µm in diameter (1 SD=39.22, N=60, 2 populations), far smaller than any other Northern Hemisphere *Isoetes* of 6× or greater. That includes the North American decaploid *I. macrospora* M. Durieu, which ranges from 600 to 800 µm (Pfeiffer 1922; Kott & Britton 1983). Similarly, averaging 39.35 µm long (1 SD=4.58, N=100, 3 populations), the microspores of the Pirin Mountain *Isoetes* are substantially smaller than those of 12× *I. creussensis* (42.8 µm) or 10× *I. lacustris* (s.s.) (45.35 µm) – the latter erroneously transcribed as 34.77 µm in Brunton et al. (2020).

The most important distinguishing morphological feature of the Pirin Mountains *Isoetes* is the congested megaspore pattern composed predominantly of tall, narrow individual muri (walls) that appear columnar or even tuberculate, and thus present the almost echinate overall appearance (Figures 4E, 5A, 6) first noted by A.C. Jermy in 1998. That contrasts markedly with the more openly-spaced ornamentation evident in other *I. lacustris* (s.l.) taxa which typically have longer, predominatly anostomosing muri in a partial to almost completely reticulate pattern (Figures 4B and 4H). The microspores (Figure 4F) appear typically to have a more mealy perispore (surface) texture and a more obscurely-rugulate ornamentation pattern than those of other *I. lacustris* (s.l.) plants (Figures 4C and 4I). They also frequently exhibit a tall, thin dorsal ridge more reminiscent of *I. creussensis* (Figure 4I; Brunton et al., 2020).

Table 1 summarizes the most significant morphological distinctions of the Pirin Mountains *Isoetes* in comparison with its most closely associated taxa.

Description

The distribution and morphological features of the Pirin Mountains *Isoetes,* in combination with its unusual ecological characteristics, confirm this isolated, subalpine-alpine component of the *I. lacustris* complex to be a genetically distinct species.

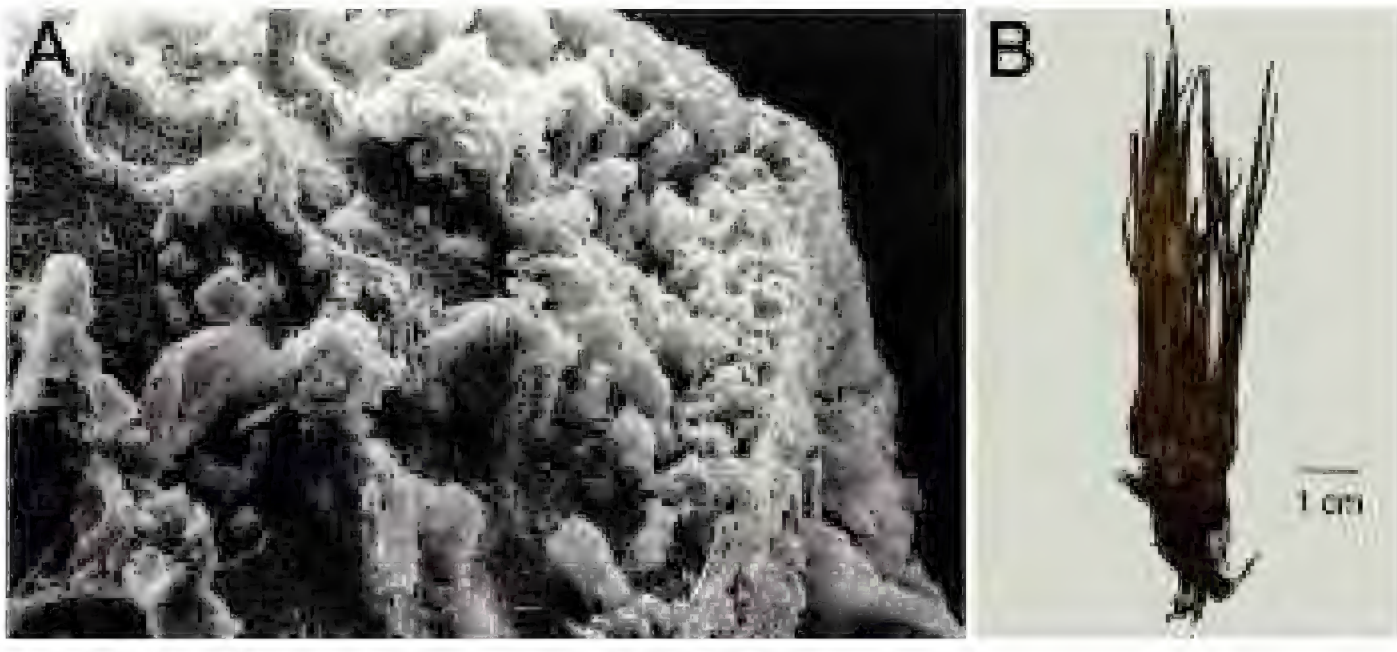

FIGURE 5: *Isoetes pirinica.* (A) details of the distal side of the megaspore with flattened, columnar tubercles presenting echinate-like ornamentation (*Ivanova s.n.*, 1998, Lake Popovo, Bulgaria); (B) Holotype of *Isoetes pirinica*, Lake Dolno Kremensko, Pirin National Park, Bulgaria, *Jermy, Ivanova & Acock 22,847*, 29 August 1998 (SOM 177407) (Photo 5A: I. Stefanova & D. Ivanova; Photo 5B: D.F. Brunton)

Accordingly, the following is proposed:

Isoetes pirinica **D.F. Brunton & D. Ivanova, sp. nov.** (Figures 2, 3, 4D, 4E, 4F, 5, 6) (*I. lacustris*. L., p.pt.)

HOLOTYPE: BULGARIA: 41.7027 °N 23.5265° E, Lake Dolno Kremensko, Pirin National Park, *A.C. Jermy, D. Ivanova & P.J. Acock 22,847**, 29 August 1998 (SOM 177407!; Isotypes: BM001073846, DFB (cytotype)!);

PARATYPES: BULGARIA: 41.7027 °N 23.5265° E, Lake Dolno Kremensko, Pirin National Park, *D. Ivanova, A.C. Jermy & P.J. Acock D-116.98*, 29 August 1998 (SOM 177431!); 41.7397 °N 23.4141° E, Lake Ribno Banderishko, Pirin National Park, *A.C. Jermy, D. Ivanova & P.J. Acock 22,839**, 28 August 1998 (BM, DFB!); *D. Ivanova, A.C. Jermy & P.J. Acock D-112.98*, 28 August 1998 (SOM 177430!); 41.7066 °N 23.5062° E, Lake Popovo, Pirin National Park, *A.C. Jermy, D. Ivanova & P.J. Acock 22,850**, 29 August 1998 (BM, DFB!); *D. Ivanova, A.C. Jermy & P.J. Acock D-118.98*, 29 August 1989 (SOM 155212!); 41.7453 °N 23.4062° E, Lake Muratovo, Pirin National Park, *A.C. Jermy, D. Ivanova & P.J. Acock 22,838**, 28 August 1998 (BM, DFB!); *D. Ivanova, A.C. Jermy & P.J. Acock D-111.98*, 28 August 1998 (SOM 177432!) (* cytologically confirmed 2n=10×=110).

PLANTS: short (6-7 cm tall, occasionally reaching 12-14 cm), herbaceous aquatic, erect to slightly arched leaves frequently spread widely by their broad bases when open-grown, arising from a two-lobed corm 0.7–1.0 cm or 1.5–2.0 cm wide (matted and open-grown plants, respectively); LEAVES: dull olive-green coloured above, whitish towards the base, rigid, spirally arranged, simple, 1.1–1.5 mm wide at mid-point (dried), narrow for most of their length, flattened and spathulate at the base, with wide membranous margins; acute-tipped; SPORANGIA: inserted into the basal inner side of the leaves; tan to brown coloured, unmarked or sparsely dark brown-spotted; 30-50% velum coverage; MEGASPORES: white at maturity, globose, averaging 516.5 µm in diameter; proximal ornamentation of narrow (columnar) and short, ±anastomosing muri; equatorial band conspicuous, composed of distinct papillae below the thin equatorial ridge; distal ornamentation congested, predominately tall, narrow (columnar) muri typically

FIGURE 6: *Isoetes pirinica* megaspores within sporangia (outer walls removed), showing congested, predominately echinate-like ornamentation pattern. (A) Lake Dolno Kremensko, *Jermy, Ivanova & Acock 22,847*, DFB (Photo: D.F. Brunton); (B) Lake Muratovo, *Ivanova, Jermy & Acock D-111.98*, SOM 177432 (Photo: D. Ivanova)

Table 1: Comparative features of *Isoetes lacustris* (s.l.) taxa (particularly distinctive features are noted in bold type)

			I. lacustris (s.s.)	***I. pirinica***	***I. creussensis***
Distribution			widespread (northern Europe)	**narrow endemic (Pirin Mts**, Bulgaria)	**narrow endemic (Pyrénées Mts**, France and Spain)
Habitat			**temperate-subarctic** (<1200 m asl)	subalpine-alpine (2050-2550 m asl)	subalpine-alpine (2000-2400 m asl)
Ploidy			2n=10×=110	2n=10×=110	**2n=12×=132**
Form			erect to arched; dispersed or mat-forming	erect to slightly arched when densely mat-forming; **widely spread** when open grown	stiffly erect when densely mat-forming; somewhat spread when open grown
leaves	cross-section (at mid-point)		oblate	typically oblate	**plumply terete**
	shape		acute-tipped	acute-tipped	**bristle-tipped**
	length		7-15 cm (50 cm)	**6-7 cm** (14 cm)	5-10 (15 cm)
megaspores	size (diameter)		626 µm	**516.5 µm**	600 µm
	ornamentation	distal side	columnar-like muri and ±anastomosing muri intermixed	**columnar-like muri congested, abundant;** ±anastomosing muri ±common	anastomosing muri predominate; columnar-like muri uncommon
		proximal side	low, up-right, loosely anastomosing muri	low to tall, columnar-like and anastomosing muri	low to **tall, flattened, folded-over** muri common
			muri and suture ridge crests smooth or (sparsely) with simple pubescence	column and suture ridge crests glabrous to obscurely pubescent	muri and suture ridge crests with **abundant recurved pubescence**
microspores	size (length)		45 µm	**39.4 µm**	43 µm
	ornamentation		smooth to mealy perispore sparsely to **boldly echinate-tuberculate**	mealy perispore, sparsely papillose to low-rugulose	smooth to fibrous perispore, plain to sparsely papillate/ low-tuberculate
			dorsal ridge wide, low to moderately pronounced	dorsal ridge wide, moderately pronounced to tall	dorsal ridge thin, **tall**; often with **drooping crest**

suggesting an echinate pattern, and with short, ±anastomosing muri intermixed; muri crests glabrous to obscurely pubescent; MICROSPORES: average 39.4 µm long; conspicuously mealy, plain to sparsely papillate; dorsal crest usually conspicuous; HABITAT: aquatic in mainly oligotrophic subalpine-alpine shallow to deep glacial lakes in coarse, quartzite/ silica sand substrate and/or fine detritus mud, growing alone or with sparse associated vegetation at 2050-2550 m asl; CHROMOSOME NUMBER: decaploid (2n=10×=110).

Etymology:— The epithet acknowledges the geographic confinement of this species to the Pirin Mountains of southwestern Bulgaria.

Origin

The typically diminutive *Isoetes pirinica* appears to have evolved during the Late Pleistocene and Early Holocene Quaternary era (11,800-7,000 years BP) in the Pirin Mountains (Stefanova & Ivanova, 2000). While fossil records of *Isoetes* in Bulgaria are rare, micro- and megaspores have been found in Holocene lake sediments in the Pirin Mountains (Stefanova & Bozilova, 1995; Stefanova & Ivanova, 2000; Bozilova et al., 2004).

Stefanova & Ivanova (2000) found both microspores and megaspores of *Isoetes pirinica* dating back 7,000 years BP in sediments from a lake in the vicinity of Lake Popovo, where it remains today. The highest percentage values in the pollen spectra fall within the interval 6,000-3,000 years BP, with the maximum abundance of *Isoetes* being noted ca. 4,000 years BP. Megaspores found in 4,000–3,000 years BP sediment were of comparable size range (470-530 µm) to that of contemporary material. The ornamentation pattern of that material (e.g. Plate I, Figures 1–6 of Stefanova & Ivanova (2000)) appears to be less echinate than is typically observed in contemporary plants, however. Based on its frequency within lake sediments, *I. pirinica* appears to have been significantly more common during the warmer Sub-boreal climatic period that characterized these sites at that time (Bozilova et al., 2004).

Microspores of an unidentified *Isoetes* are reported from Late glacial and Holocene sediments in the Western Rhodope mountains of Bulgaria, adjacent to the Pirin Mountains (Huttunen et al., 1992). These were dated from 12,000 to 9,000 years BP, with sporadic occurrences as recently as 6,800 years BP. Recent palynological data from the same site as Huttunen et al. (1992) determined these microfossils to actually date from ca. 30,000 years BP, with their maximal abundance occurring between 30,000 and 20,000 years BP (Lazarova et al., 2012).

There is significant question, however, whether the Western Rhodopes material actually represents *Isoetes*. The absence of megaspores from sediment samples representing a 10,000-year period during which *Isoetes* microspores are reported to be abundant, is inexplicable. No other palynological studies reporting *Isoetes* are known to have exclusively found microspores. Further, at ca. 20 µm in length (Figure 2 – Lazarova et al., 2012), these Western Rhodopes objects would be exceptionally (uniquely?) small amongst both contemporary and fossil *Isoetes*. They also apparently do not exhibit the dorsal ridge typically present on all *Isoetes* microspores and which are particularly conspicuous in *I. pirinica*. The small size of these objects is additionally difficult to explain when the most likely source would be the adjacent Pirin Mountains 10× species that has microspores almost 100% larger than this (Table 1). Accordingly, confirmation of the identity of the Western Rhodopes objects is required before those findings can be employed in addressing the origins of *I. pirinica*.

The probability that *Isoetes pirinica* represents a recently evolved species conforms

with the recognition of *I. creussensis* in the Pyrénées Mountains of western Europe (Lazare & Riba, 2000, Brunton et al., 2020) and *I. laurentiana* D.F. Brunton in eastern Canada (Brunton et al., 2019). Both are from similarly restricted habitats that were long submerged beneath glacial ice until at least 14,000 years BP.

Conservation Status

Isoetes pirinica (under the name *I. lacustris*) is legally protected by the Bulgarian Biological Diversity Act (BDA) and included in its Annex 3 (2002, 2007). The species and its habitat are both evaluated as 'Endangered' at a national level in the Red List and the Red Data Book, respectively (Ivanova, 2009, 2015; Ivanova & Roussakova, 2015). Oligotrophic mountain lakes as a habitat are included in Annex 1 of BDA (2005) and evaluated as 'Vulnerable' at national level (Kozhuharov & Ivanov, 2015).

The range of *Isoetes pirinica* is entirely within Pirin National Park, which is both a UNESCO World Heritage Site (UNESCO, 2021) and a site within the European Ecological Network NATURA 2000 (BG0000209 'Pirin'). Some of the *Isoetes* lakes are also within the borders of the Yulen Nature Reserve. The Pirin Mountains constitute a unique ecosystem and one of Europe's most important biodiversity hotspots, characterized by exceptional plant diversity and a high percentage of endemic taxa. This is the second richest region for endemic taxa in Bulgaria, with 176 endemic taxa (out of 444 for the country as a whole). Forty of these are uniquely Bulgarian and 136 represent Balkan endemics (Petrova & Vladimirov, 2010).

Despite the designated legal protection measures, some threats to the habitat and consequently to the species still exist. Due to anthropogenic pressure caused by tourist traffic and the intensive grazing of free ranging livestock in the high mountain regions, there is significant pollution of organic and other type of waste in some lakes, especially (but not exclusively) those near chalets. Eutrophication of such lakes and the conversion of the natural vegetation is already evident (D. Ivanova, pers. obs.), although at an early stage.

Although confined to a small geographic area and restricted to an ecologically sensitive habitat, *Isoetes pirinica* is locally abundant and appears to have a self-sustaining population. Accordingly, notwithstanding the anthropogenic pressures noted above and possible long term negative implications of global climate change, the conservation prognosis of the species appears to be positive.

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The study is only possible because of the field and laboratory investigations in the 1990s of the late Clive Jermy, Natural History Museum, London, UK and the late Donald Britton, University of Guelph, Guelph, Ontario, Canada. We greatly appreciate the data, insights and enthusiasm they shared, including the specimens of Jermy and access to SEM imagery and cytological data of Britton. Thanks are also due to Angelo Troia, University of Palermo, Palermo, Italy for assistance obtaining pertinent literature, as well as to Rumen Kolchagov (then Pirin National Park staff) who was a very helpful guide during the 1998 expedition. Similarly, we are grateful to Fred Rumsey, Alison Paul and Pat Acock of the Natural History Museum, London, UK, for data regarding Jermy's collections in BM. Our thanks to Pat Acock for also sharing his photos and recollections of the 1998 Pirin field trip. We appreciate the efforts of the curatorial staff of the herbaria cited for enabling access to the material in their care.

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BOOK REVIEW

An annotated checklist of Indian Pteridophytes, Part 3 (Lomariopsidaceae to Salviniaceae). Fraser-Jenkins, C.R., Gandhi, K.N. & Kholia, B.S. 2021. pp 450. Bishen Singh Mahendra Pal Singh, Dehra Dun, India. Price US $ 95.00, £75.00, Euro 90.00.

Reviews of *Parts 1(Lycopodiaceae to Thelypteridaceae)* and *2 (Woodsiaceae to Dryopteridaceae)* of *An annotated checklist of Indian Pteridophytes* were published in The Fern Gazette, Vol. 20, Part 3, in 2016 and Vol. 20, Part 6, in 2019. This third and final volume follows the same format, but covers the families Lomariopsidaceae to Salviniaceae and an appendix with corrections and additions to Parts 1 and 2.

The taxonomic treatments in Part 3 cover the families Lomariopsidaceae, Oleandraceae, Nephrolepidaceae, Davalliaceae, Polypodiaceae, Grammitidaceae and Salviniaceae. As in the previous parts, the classification of families and genera used by the authors often deviates from PPG I (2016), but the approach used is clarified in each case. Thus, for example, in PPG I (2016) Grammitidaceae is included within Polypodiaceae but treated as a separate family here, and whereas a single genus is recognised in Davalliaceae in PPG I (2016), six genera are recognised here - *Araiostegiella*, *Davallia*, *Davallodes*, *Katoella*, *Leucostegia* and *Paradavallodes*.

For each taxon valuable details of type material are provided, with synonyms and distribution followed by often extensive notes. These notes cover various topics that include mis-application of names, incorrect records, morphological variation within the taxon, or features that distinguish it from similar taxa and, for threatened taxa, their designated IUCN Red List status in India.

Again the volume is greatly enhanced by the inclusion of 204 excellent coloured plates, sometimes herbarium material but the majority showing living plants in the field, often with close-ups of sori or rhizomes, and including some magnificent images of epiphytes.

The authors are to be congratulated on completion of this very comprehensive taxonomic revision of all the pteridophytes of India, provided a much needed, accurate base-line for future work that will be of value not only in India but more widely across Asia.

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MARY GIBBY

CALYMMODON PECTINATUS, A NEW SPECIES OF GRAMMITID FERN (POLYPODIACEAE) FROM MALESIA

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Key Words: *Calymmodon pectinatus*, Malesia, Grammitidoideae, Polypodiaceae

ABSTRACT

A new species of grammitid fern, *Calymmodon pectinatus* (Polypodiaceae) is described from Malesia.

INTRODUCTION

A monographic study of *Calymmodon* C.Presl (Parris, in. prep) currently recognises 63 species, with 48 in Malesia, the centre of the genus (Parris, 2018). The treatment of the genus for the Flora Malesiana account of grammitid ferns (Grammitidoideae: Polypodiaceae) (Parris, in prep.) necessitates the description of several new species: *Calymmodon pectinatus*, described here, is the most widespread of these, ranging from Sumatra to Papua New Guinea (Figure 1).

TYPIFICATION AND DESCRIPTION

Calymmodon pectinatus *Parris,* **sp. nov.**

Synonymy: *Calymmodon redactus* Parris sp. nov. in prep., Ebihara et al., Bull. Natl. Mus. Sci., Ser. B, 38(3): 112 (2012). *C. gracillimus auct. non* (Copel.) Nakai ex H.Ito: Kato & Parris, J. Fac. Sci. Univ. Tokyo 3, 15: 122 (1992) *quoad Kato et al.* C-1313 (TI!), C-2999 (TI!), C-3587 bis (TI!), C-5664 (TI!), C-7750 p. p. (TI!), C-12054 (TI!), C-12481 (TI!), C-14377 (TI!). *C. poensis* Parris *in herb.*

Type: INDONESIA, Maluku Province, Central Seram, Tehoru District, Manusela

Figure 1. Distribution of *Calymmodon pectinatus*

National Park, trail from Hatumete to Gunung Hoale Besar, southern slope of Murkele Ridge, 3°13-14'S 129°34'E, 1300-1820 m, 8 September 1986, *M Kato, K Ueda & Z Fanani* C-14377 (holotype TI!, lower left hand plant; isotypes BO, L!, TI!).

Etymology: Latin, *pectinatus* = with narrow divisions like a comb, referring to the shape of the sterile pinnae.

Diagnosis: *Calymmodon pectinatus* can be distinguished from all other members of the genus by the following combination of characters: lamina narrowly lanceolate to linear-lanceolate, membranous to chartaceous, rarely glabrous, usually with 1-5-branched hairs with setae as branches and/or setae, both types of hair 0.1-0.2 mm long; hydathodes present on vein endings on adaxial surface of lamina; longest fertile pinnae from < 1/2 to up to 2/3 as long as longest sterile pinnae on a frond; fertile pinnae not stalked, lacking

Figure 2. *Calymmodon pectinatus*. Whole plant *in situ*: c. 8 cm long. Photo: Cheng-Wei Chen, reproduced with permission.

setae on adaxial surface of vein; vein in sterile pinnae never forked; sterile pinnae very narrowly oblong or narrowly oblanceolate to narrowly elliptic, longest sterile pinnae on each frond 3-7 x longer than wide, separated by twice their width or more (Figures 2-5). Description: Rhizomes (1.4-)2.2-4.7(-7.0) mm diam. including stipes, 0.4-0.5 mm diam. without stipes, erect, not branched, radial, stipes in whorls, not articulated to rhizome, phyllopodia absent; scales 1.8-2.5(-2.8) x 0.3-0.6(-0.7) mm, lanceolate to narrowly lanceolate, acute at apex, subcordate to pseudopeltate at base, pale to medium red-brown or pale yellow-brown, glabrous or with 1 whitish or pale red-brown seta 0.1-0.2 mm long at apex or 1 whitish or pale red-brown 1-3-forked hair with catenate base, setae as branches and glandular apex 0.1-0.2 mm long at apex, not clathrate, not iridescent, subglossy to glossy, cells turgid or not. Stipes ± winged to base. Laminae (28)42-111(-230+) x (4-)5-8(-10) mm, narrowly lanceolate to linear-lanceolate, obtuse to acuminate at apex, long-attenuate at base, usually deeply pinnately divided to wing 0.1-0.2 mm wide along rachis, rarely pinnate, pinnae dimorphic, fertile pinnae in distal part of frond, folded over sori, pinnae (9)15-39(-83+) pairs, lowest 1(-2) pairs sometimes reduced to auricles, fertile pinnae at (20-)42-73(-90) to rachis, (0-)1-3(-4) mm apart, longest fertile pinnae (1.3)1.8-3.0(-4.6) x (0.3-)0.6-1.0(-1.4) mm folded, x (0.6-)1.0-1.6(-2.1) mm unfolded, obovate, oblanceolate, elliptic, or triangular when folded, obovate to oblanceolate when unfolded, obtuse to acuminate at apex, adnate to slightly surcurrent on acroscopic margin, decurrent on basiscopic margin at base, entire, lowest fertile pinnae shorter than uppermost sterile pinnae, longest fertile pinnae from < 1/2 to 2/3 as long as longest sterile pinnae on a frond, sterile pinnae at (20-)47-77(-95) to rachis, (1-)2-3(-4) mm apart, longest sterile pinnae (1.8-)2.8-4.6(-6.7) x (0.4-)0.6-1.0(-1.3) mm, 3-7 x longer than wide, separated by twice their width or more, very narrowly oblong to narrowly

Figure 3. *Calymmodon pectinatus*. Whole plant: c. 8 cm long. Photo: Cheng-Wei Chen, reproduced with permission.

oblanceolate or narrowly elliptic, obtuse to acuminate at apex, adnate to surcurrent on acroscopic margin, decurrent on basiscopic margin at base, entire; texture membranous to chartaceous; rarely glabrous, usually with ± appressed whitish, pale yellow-brown or pale to medium red-brown 1-5-forked hairs 0.1-0.2 mm long with catenate base, setae as branches and glandular apex on abaxial surface of rachis, rarely on abaxial surface of lamina adjacent to rachis, abaxial surface of vein, margin and adaxial surface of rachis, sometimes with ± patent pale red-brown or pale yellow-brown setae 0.1-0.2 mm long on abaxial surface of lamina, vein and rachis, margin and adaxial surface of rachis; rachis slightly prominent to prominent on abaxial surface, prominent on adaxial surface, concolorous to darker on both surfaces; veins simple, visible in transmitted light, usually slightly prominent to prominent on both surfaces, concolorous to darker on abaxial surface, concolorous to slightly darker on adaxial surface of lamina, not extending beyond sorus, each vein ending with a pale to dark ± circular to elongate hydathode 0.1-0.5 x 0.1 mm on adaxial surface of lamina, free. Sori (0.8-)1.2-1.7(-2.2) x (0.4-)0.7-1.2(-1.8) mm, ± circular to broadly elliptic in outline, with lamina completely or incompletely folded over them, on (1-)4-24(-70+) pairs of pinnae, in apical 1/10 to 5/6 of lamina, to 0-4(-7) mm below lamina apex, 1 per pinna, on vein, in middle to apical 1/3 to 2/3 of pinna to ± throughout, to 0-1 mm below pinna apex. Sporangia (130-)150-180(-220) µm, glabrous; indurated cells of annulus (9-)11-12(-14). Spores (20-)22-29(-39) µm diam.

Paratypes: INDONESIA. Sumatra: Tapanuli: Lae Pondom, east of Sidikalang, 29 March 1954, *Alston* 14906 (BM!). Siboeatan-Zuid, 1800 m, 10 April 1941, *Surbeck* 638 (L!). Java: Halimun National Park, 28 Oct. 2011, *Wade* 2020 (TAIF!); Salak West, *Raciborski* s. n. (BO, L!); Tjibodas, *de Monchy* s. n. (L!), 25 May 1890, *Raciborski* s. n. (BO, L!); Pangrango, *de Monchy* s. n. (BO!); Baturaden to Gunung Slamat, 2000-2600 m, 18 Aug.

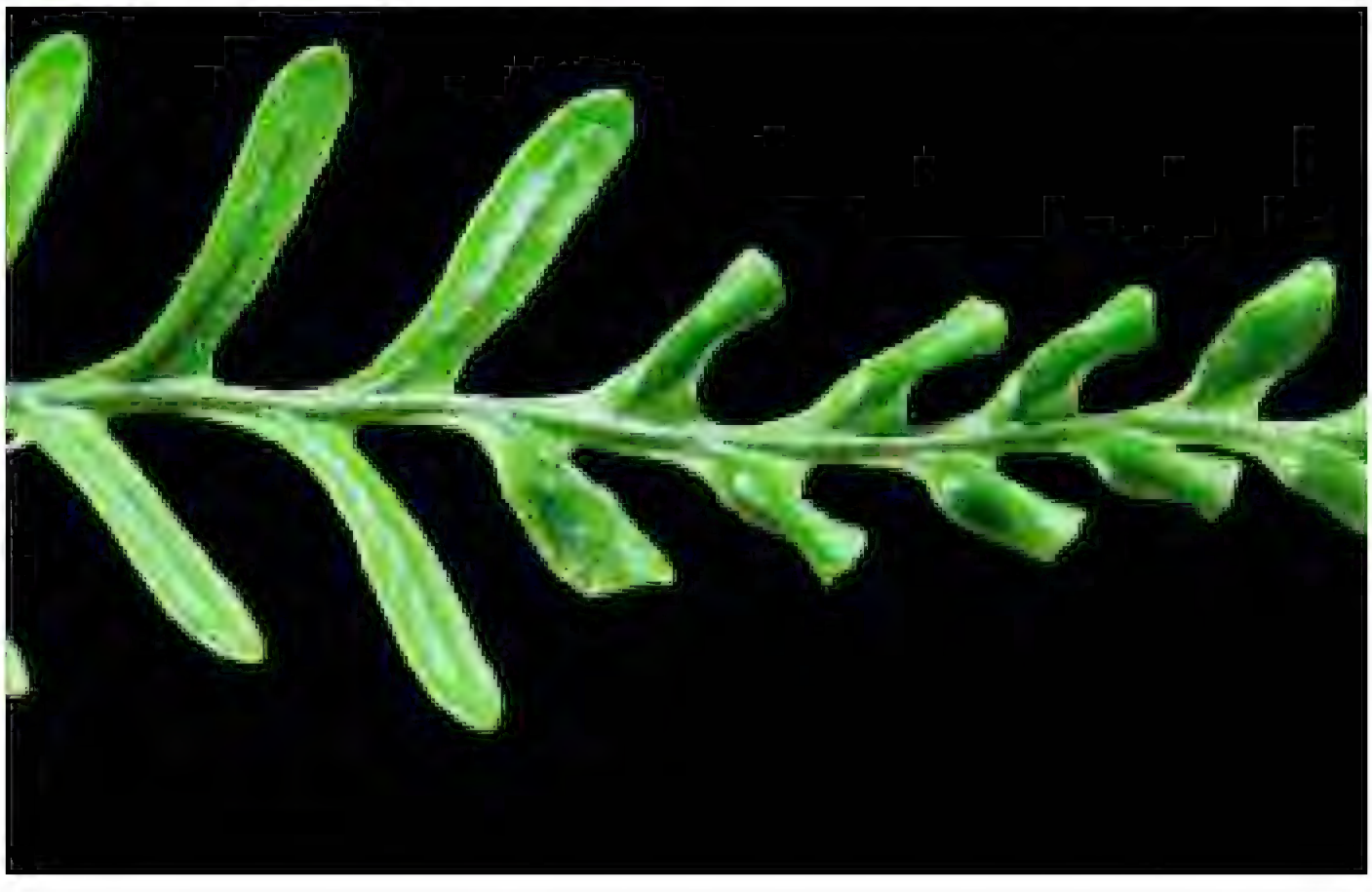

Figure 4. *Calymmodon pectinatus*. Upper part of frond, adaxial surface: uppermost sterile pinna c. 4 mm long. Photo: Cheng-Wei Chen, reproduced with permission.

1972, *Murata et al.* J-788 (BO, L!, TI); Slamat, 1898, *Raciborski* s. n. (KRA, L!); Gunung Lawoe, c. 1433 m, 1922, *Rant* s. n. (BO!); Mt Sagal, *Horsfield* 827 (BM!); Mt Idjen, 1520 m, 24 Oct. 1858, *Zollinger* 323 (L!); without locality: *Horsfield* s. n. (BM!), *Moehl* s. n. (L!), *Reinwardt* s. n. (L!), *Wichura* 2309 (B!). Maluku: Halmahera: Peak of Jailolo, summit ridge, 13 Aug. 1954, *Alston* 16859 (A, B, BM!, BO, BRI, L!, P, PNH, SING, US): Seram: Seram Utara: Manusela National Park: Goa Pohon Damar to Gunung Roihelu, south of Sawai, 3°02-03'S 129°11-12'E, 1080-1530 m, 26 Jan. 1985, *Kato et al.* C-5664 (TI!); north slopes of Gunung Binaiya, Wae Ansela to Wae Huhu, 3°08-09'S 129°29'E, 1290-2000 m, 3 Jan. 1985, *Kato et al.* C-3587 bis (TI!); Seram Utara and Tehoru: Manusela National Park: Hatumete to Maraina in Manusela Valley via Hoale Pass in Murkele Ridge, 3°12'S 129°36'E1, 810-1770 m, 18 Nov. 1983, *Kato et al.* C-1313 (TI!): Tehoru: Jalan Lelesiru from Piliana to Gunung Ohae, south slope of Murkele Ridge, 3°13-14'S 129°32'E, 900-1600 m, 25 July 1986, *Kato et al.* C-12054 (TI!); Jalan Pipileina from Piliana to Gunung Sinaunia, south slope of Murkele Ridge, 3°13-14'S 129°34'E, 1390-2030 m, 29 July 1986, *Kato et al.* C-12481 (BO, TI!); Hatumete to Hoale Pass, S slope of Murkele Ridge, 3°14'30"S 129°36'30"E, 550-1770 m, 21 Feb. 1985, *Kato et al.* C-7750 p. p. (TI!).

MALAYSIA. Sabah: Mount Kinabalu: Marai Parai, 1520 m, 19 May 1933, *Clemens* 39161 (A, B!, BO!, BRI, K!, L! NY, PNH, U); Bukit Burong trail, c. 1500 m, 23 Oct. 1980, *Parris* 9166 *& Croxall* (K!). Sarawak: 4th Division: Marudi: Gunung Mulu National Park: Gunung Mulu, 1250-1370 m, 28 June 1961, *Keng* 848C p. p. (L!); Gunung Mulu, west ridge, c. 1200 m, 18 June 1978, *Parris* 6526 *& Croxall* (K!); Gunung Mulu, west ridge, Sungei Tapin headwaters, c. 1750 m, 24 June 1978, *Parris* 7106 *& Croxall* (K!); Gunung Mulu, Camp 1 to Camp 3, summit trail, 2019, *Wade* 5881 (TAIF images!): 1st Division: Lundu: Gunung Pueh (Poe) summit, July 1908, *Tee Koo* in *Hewitt* 32 (SAR!).

BRUNEI. Temburong: Gunung Retak, ridge south of helicopter pad, 4°21'N 115°17'E,

Figure 5. *Calymmodon pectinatus*. Lower part of frond, adaxial surface: uppermost sterile pinna c. 4 mm long. Photo: Cheng-Wei Chen, reproduced with permission.

1300-1350 m, 9 March 1991, *Johns* 6578 *et al.* (BRUN, K!).
PHILIPPINES. Palawan: 2021, *M D Angeles* s. n. (PNH images!). Mindanao: Misamis Occidental: Mount Malindang, *Amoroso CMU* 1248 (CMU!): Davao: Mount Apo, Coong, 7°N 125°15'E, 1920 m, 6 May 2012, *Kuo* 2687 (AK!, TAIF).
PAPUA NEW GUINEA. Milne Bay: Maneau Range, north slopes of Mount Dayman, 900 m, 22 July 1953, *Brass* 23622 (A, BM!): East New Britain: Pomio: Mount Sule, c. 25 miles NNE of Fulleborn Harbour, 5°50'S 150°50'E, 1500 m, 7 May 1973, *Croft & Katik NGF* 14926 (A, BRI, CANB, E!, K!, L, LAE, M).
Ecology and Distribution: Low epiphyte on mossy tree trunks in light to deep shade, in lower montane forest, midmontane forest and upper montane tall forest, on limestone and sandstone, growing with hepatics, mosses and *Hymenophyllum*, recorded as rare; from 1200 to 2000 m. Known from Indonesia (Sumatra, Java, Maluku), Malaysia (Sabah, Sarawak), Brunei, the Philippines and Papua New Guinea.

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THREE NEW HYBRIDS OF JAPANESE CORNOPTEROID FERNS IN THE GENUS *ATHYRIUM* (ATHYRIACEAE)

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Key Words: *Athyrium*, *Cornopteris*, hybrid, Japan

ABSTRACT

The morphological characteristics of three new hybrids from the islands of Honshu, Kyushu and Shikoku, Japan are described: *Athyrium* ×*decurrentiserratum*, *A.* ×*pseudobipinnatum* and *A.* ×*subchristensenianum*, and comparisons made with closely related species.

INTRODUCTION

Cornopteris is a genus of terrestrial fern in the small family Athyriaceae (Polypodiales: Aspleniineae), characterized by its fleshy stipes, corniculate leaf axes, and exindusiate sori (Nakai, 1930; Itô, 1939; Ching, 1945; Holttum, 1958; Tagawa, 1959; Kato, 1977; 1979; Hori, 2020a; 2020b). Cornopteroid species of the genus *Athyrium* are distributed mainly in the Himalaya, in East and Southeast Asia. Previously, Kato (1979) classified nine species of cornopteroid ferns; later, Zhaorong and Kato (2013) recognized 16 species from China. Serizawa (1981) merged *Cornopteris* into the genus *Athyrium* because some intergeneric hybrids between *Athyrium* and *Cornopteris* exist, including *Athyrium* ×*cornopteroides* Sa.Kurata (*Cornopteris opaca* (D.Don) Tagawa × *Athyrium kuratae* Seriz.), *Athyrium* ×*glabrescens* Seriz. (*C. decurrentialata* (Hook.) Nakai × *A. kuratae*), and *Athyrium* ×*petiolatum* Sa.Kurata (*C. opaca* × *Athyrium yakushimemse* Tagawa). More recently *Cornopteris* spp. have been classified as part of *Athyrium* based on DNA phylogenies (Rothfels et al., 2012; PPG I, 2016; Ebihara, 2017; Hori, 2020b). However, Moran et al. (2019) distinguished the genus *Cornopteris* from *Athyrium* based on plastid DNA phylogeny. In the present study, *Cornopteris* spp. are treated as members of *Athyrium*, following PPG I (2016).

The following is a brief history of the classification of one *Athyrium* species, namely *A.* ×*christensenianum* (Koidz.) Seriz., which was first described by Koidzumi (1924) as *Diplazium christensenianum* Koidz. from Jeju Island, South Korea. Later, Kato (1979) treated *Cornopteris hakonensis* Nakai from Hakone, Japan (Nakai, 1930) as a synonym of *Cornopteris christenseniana* Tagawa. Subsequently, Serizawa (1981) classified this taxon within the genus *Athyrium* as a hybrid as it is triploid. It is considered by Japanese pteridologists to result from a cross between diploid sexual *A. crenulatoserrulatum* Makino and tetraploid sexual *A. decurrentialatum* (Hook.) Copel. (Kurita, 1964; Hirabayashi, 1970; Kato 1979; Park & Kato, 2003), because it has intermediate morphological characteristics such as serrated segments, subcartilaginous margins of the lamina, and elliptical sori. From the treatment of this taxon, it remains unclear whether it is merely a sterile hybrid or an independent fertile species.

Recent studies have uncovered further taxa with the *A.* ×*christensenianum* complex. First, Hori and Murakami (2019) reported a tetraploid sexual cytotype of *A.* ×*christensenianum* and Hori (2019), based on molecular studies of the nuclear DNA genes *AK1* and *PgiC*, showed that tetraploid sexual *A. christensenianum* had one allele

of *A. crenulatoserrulatum* and one of *A. decurrentialatum*, and that triploid *A. ×christensenianum* had two alleles of *A. crenulatoserrulatum* and one allele of *A. decurrentialatum*. He suggested two hypotheses: (1) tetraploid sexual *A. christensenianum* originates from the hybridization of diploid sexual *A. crenulatoserrulatum* and an ancestral or extinct diploid *A. decurrentialatum*, with subsequent chromosome doubling; and (2) triploid *A. ×christensenianum* originates from the hybridization of diploid sexual *A. crenulatoserrulatum* and tetraploid sexual

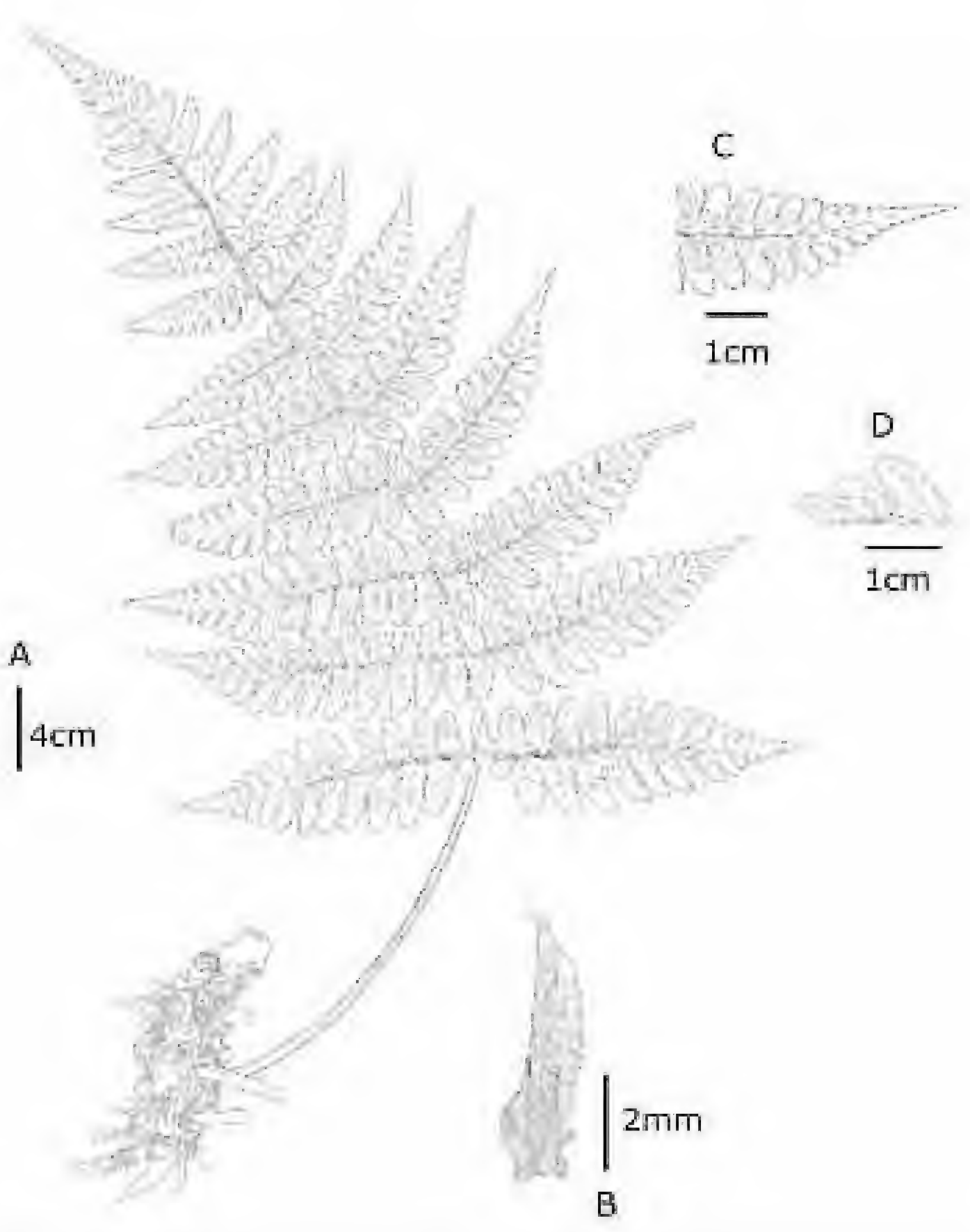

Figure 1. *Athyrium ×decurrentiserratum* K.Hori. **A** habit, **B** lower stipe scale, **C** detail of abaxial pinnae, **D** detail of adaxial pinnae. **A-D** from the holotype (MAK466750) (illustration by K. Hori).

A. ×*christensenianum*. Hori (2020a) described this tetraploid sexual type as *Athyrium bipinnatum* K.Hori. However, this description does not sufficiently explain the complexity of *A.* ×*christensenianum* complex.

Hori (2020b) also recognized five genotypes of *A.* ×*christensenianum* based on ploidy analysis and DNA markers. Based on plastid (*rbcL*) and nuclear (*AK1*) DNA phylogeny, Hori (2020b) resolved the relationships between *A. crenulatoserrulatum* (genome A), *A. decurrentialatum* (B), and *A. opacum* (C) as follows: type AABB (tetraploid sexual = *A. bipinnatum*); type AAB (triploid sterile=*A.* ×*christensenianum*); type ABB (triploid sterile); type ABBB (tetraploid sterile); and type ABC (triploid sterile). In addition, Hori (2020b) suggested the existence of an undetected tetraploid sexual species that originates from a hybrid between ancestral diploid sexual *A. decurrentialatum* and diploid sexual *A. opacum* to explain the origin of type ABC.

The morphological characteristics of three new hybrids, *Athyrium* ×*decurrentiserratum* (ABB), *A.* ×*pseudobipinnatum* (ABBB), and *A.* ×*subchristensenianum* (ABC) are described.

Taxonomic treatment

Athyrium ×decurrentiserratum *K.Hori* **hyb. nov.** (Figure 1)

Type: Japan, Honshu: Tokyo-to, Ome city, Koshizawa, 35°48'12.62"N, 139°08'5.62"E, 396 m alt., planted coniferous forest containing *Cryptomeria japonica* (Thunb. ex L.f.) D.Don, on soil, June 4 2018, *Hori 2981* (holotype MAK466750!, isotypes MBK!).

Diagnosis: Similar to *A. decurrentialatum* with decurrent pinnules, but pinnules more serrated at the margins. Also similar to *A. decurrentialatum* (Hook.) Copel. f. *latifrons* H.Ito in having serrated pinnules, but these are lighter green in colour. Sporangia shrunken, spores abortive and irregular-shaped. $2n = 120$ (Figure 2), triploid.

A primary hybrid of *A. crenulatoserrulatum* and *A. decurrentialatum* (Hori, 2020b).

Description: Terrestrial summer-green fern. *Rhizomes:* creeping, occasionally two-branched, stramineous, 5–15 cm long, 1.5–2.0 cm in diam., closely set with roots, and persistent, densely clothed, old stipe bases, glabrous; *fronds:* 2–5 per rhizome; *stipes:* stramineous or slightly purple-red, 7–30 cm long, 0.5–0.8 cm in diam., sparsely clothed with stramineous to dark brown basal scales (3.0–6.0 mm long, 1.0–1.5 mm wide), lanceolate; *blades:* light green on adaxial surface, two-pinnate or two-pinnate pinnatifid at the base, one-pinnate pinnatifid in the middle to upper section, pinnatifid at the apex, 20–50 cm long, 25–30 cm wide, narrowly ovate; *rachises:* stramineous or slightly purple-red to dark brown, abaxially densely pilose, several projections 0.1-mm long on

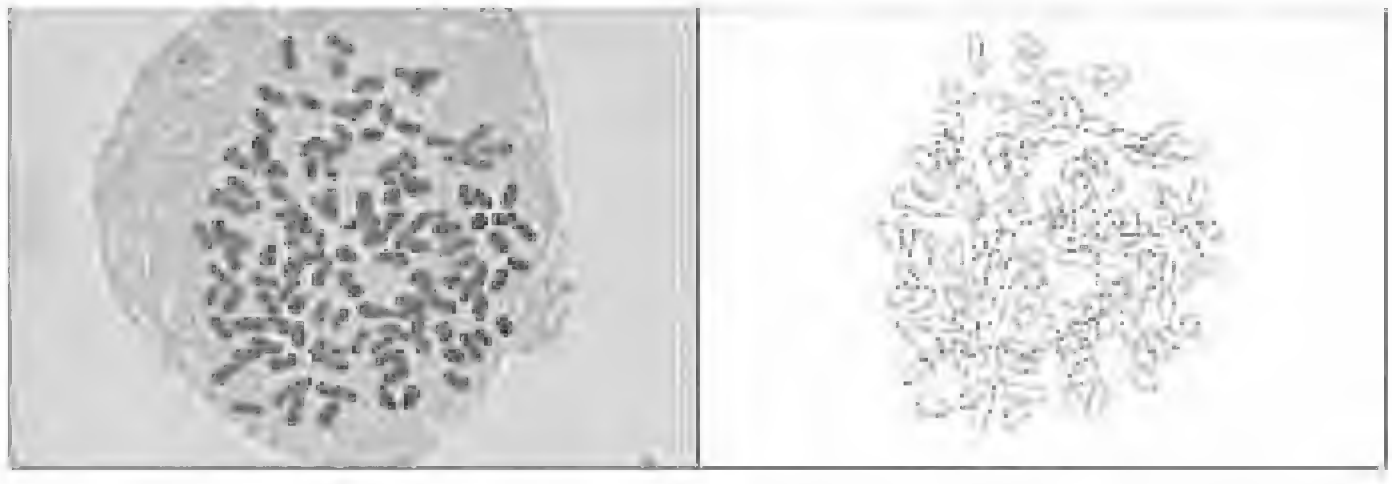

Figure 2. Photograph and sketch of mitotic chromosomes of *A.* ×*decurrentiserratum* (MAK466750), $2n = 120$.

the adaxial surface at the bases of costae; *pinnae:* 10–11 pairs, ascending, lanceolate, alternate or opposite, petioled (2–4 mm long), sessile near the apex, widely spaced, lowest pinnae slightly reduced, or the same as second, second lowest pair usually largest, 10–20 cm long, 3–7 cm wide; *pinnules*: alternate, 10–13 pairs on the basal and middle sections of the blade, 8–10 pairs on the apex of the blade, reduced distally, ovate to lanceolate, serrate to lobed, vein-free, close to or reaching to the margin, 3–8 pairs in the middle lobe; *the most basiscopic pinnules on the lowest pinnae:* clearly short, independent from the costa, 0.5–1.0 cm long, 0.5–0.6 cm wide; *sori:* short linear- or V-shaped, 1.5–3.0 mm long, on the apex or middle of veinlets, 1–5 pairs per ultimate segment, exindusiate, somewhat persistent; *spores:* irregular shaped, abortive. $2n = 120$, triploid.

Etymology: *A.* ×*decurrentiserratum* is named as a new hybrid with decurrent and serrated pinnules.

Specimens examined: Japan. Honshu: Akita pref., Minamiakita-gunn, Gojome-machi, Mt. Moriyama, on soil under planted coniferous forest containing *Cryptomeria japonica*, ca. 80 m alt., 6 Jul 2020, coll. *K.Hori 3388* (MAK 467053); Ishikawa pref., Kanazawa-shi, Kenjo-machi, 27 Jul 1963, coll. *N.Satomi24613* (MAK 95016); Niigata pref., Kashiwazaki-shi, Mt. Kurohimeyama, 830 m alt., 8 Nov 1999, coll. *T.Tamura 750* (TNS 01196920, image!); Kanagawa pref., Hakone-machi, Hatajuku, 4 Sep 1982, coll. *K.Tanaka* (MBK0158996); Saitama pref., Iruma-gunn, Naguri-mura, Arimadani, 12 Sep 1973, coll. *K.Suzuki 4757* (MAK 267915); Tochigi pref., Kanuma-shi, Mt. Ozakusan, 8 Jul 2020, coll. *K.Hori 3400* (MAK 467065); Hyogo pref., Tsuna-gun, Hokudan-cho, Mt. Jouryuji-san, 450m alt., 15 Jul 1989, coll. *T. Kobayashi 13631* (KYO); Tottori pref.,

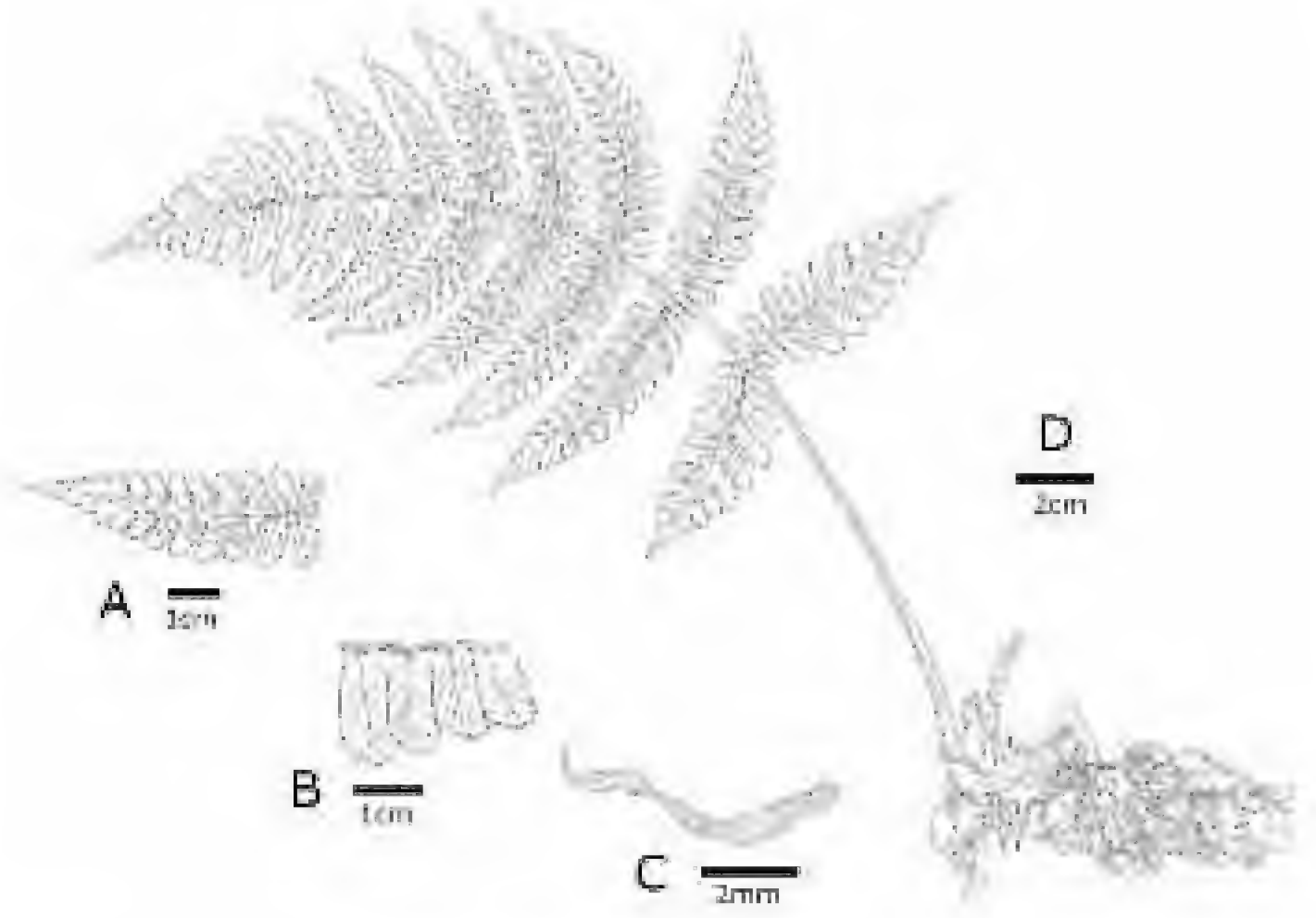

Figure 3. *Athyrium* ×*pseudobipinnatum* K.Hori. **A** detail of abaxial pinnae **B** detail of adaxial pinnae, **C** lower stipe scale, **D** habit. **A-D** from the holotype (MAK466761) (illustration by K. Hori).

Yazu-gun, Wakasa-cho, Yoshikawa, 650m alt., 10 Aug 2008, coll. *K. Hirano 5566* (KYO); Osaka-fu., Izumi-shi, Chichioni-cho, 18 Sep 1988, coll. *I.Yamazumi* (TNS 933817, image!).
Distribution and Ecology. Honshu, Japan, growing on soil under planted coniferous forest of *Cryptomeria japonica* at ca. 50-1000 m alt.

Athyrium ×pseudobipinnatum *K.Hori* **hyb. nov.** (Figure 3)
Type: Japan, Kyushu: Fukuoka pref., Itoshima city, Shiraito, 33°28'45"N, 130°10'33"E, 515 m alt., planted coniferous forest containing *Cryptomeria japonica*, on soil, June 23 2019, *Hori 3274* (holotype MAK466761!, isotypes MBK!).
Diagnosis: Similar to *A. bipinnatum* and *A. decurrentialatum* with fronds having a dark green surface, but with more entire pinnules on the margin than *A. bipinnatum*; *A. ×pseudobipinnatum* has more basiscopic pinnules on the lowest pinnae, which are clearly short and independent from the costa. It has bipinnate blades, which distinguish it from *A. ×christensenianum*. Sporangia shrunken, spores abortive and irregular shaped.
Description: Terrestrial summer-green fern. *Rhizomes:* creeping, occasionally two-branched, stramineous, 5–15 cm long, 1.5–2.0 cm in diam., closely set with roots and persistent, densely clothed old stipe bases, glabrous; *fronds:* 2–5 per rhizome; *stipes:* stramineous or slightly purple-red, 7–30 cm long, 0.3–0.6 cm in diam., sparsely clothed with stramineous to dark brown basal scales (3.0–6.0 mm long, 1.0–1.5 mm wide), lanceolate; *blades:* dark green on adaxial surface, two-pinnate at the base, one-pinnate pinnatifid in the middle to upper section, pinnatifid at the apex, 15–50 cm long, 15–30 cm wide, widely ovate; *rachises:* stramineous or slightly purple-red, dark brown, abaxially densely pilose, several projections 0.1-mm long on the adaxial surface at the bases of costae; *pinnae:* 7–11 pairs, ascending, lanceolate, alternate or opposite, petioled (1–3 mm long), sessile near the apex, closely spaced, lowest pinnae slightly reduced, second lowest pair usually largest, 10–20 cm long, 3–7 cm wide; *pinnules*: alternate, 7–15 pairs on the basal and middle sections of the blade, 5–10 pairs on the apex of the blade, reduced distally, ovate to lanceolate, entire, vein-free, close to or reaching to the margin, 3–8 pairs in the middle lobe; *the most basiscopic pinnules on the lowest pinnae:* clearly short, independent from the costa, 0.5–1.0 cm long, 0.5–0.6 cm wide; *sori:* short linear- or V-shaped, 1.5–3.0 mm long, on the apex or middle of veinlets, 1–5 pairs per ultimate segment, exindusiate, somewhat persistent; *spores:* irregularly shaped, abortive. *Athyrium ×pseudobipinnatum* is a hybrid between *A. bipinnatum* and *A. decurrentialatum* (Hori 2020b). Chromosome number unknown, ploidy level was estimated to be tetraploid based on DNA content of fresh pinnae (Hori 2020b).
Etymology: *A. ×pseudobipinnatum* is similar to *A. bipinnatum*.
Specimens examined: Japan. Honshu: Osaka-fu, Kawachinagano-shi, Mt. Iwawaki-san, Sep. 1933 (date unknown), coll. *T. Makino* (MAK 66814); Wakayama pref., Kaiso-gunn, Nokami-cho, Nakada, Tateiwafudou, 12 Nov 1978, coll. *H.Masago* (TNS 942253, image!). Shikoku: Kochi pref., Tosa-gunn, Hongawa-mura, 5 Aug 1953, *H.Inoue 1344* (TNS 1035799, images!). Kyushu: Kumamoto pref., Aso-gun, Kugino-son, Komagaeshi-pass, 800m alt., coll. *M. Furuse 53250* (KYO), Miyazaki pref., Ebino-shi, Mt. Kuruson-yama, 11 Aug 1976, *K.Suzuki 7251* (MAK282245, image!).
Distribution and Ecology: Found in the western part of Honshu, and in Shikoku and Kyushu, Japan, growing in soil under planted coniferous forest of *Cryptomeria japonica* at ca. 500-900 m alt.

Athyrium ×subchristensenianum *K.Hori* **hyb. nov.** (Figure 4)

Type: Japan, Honshu: Akita pref., Yurihonjo city, Hachinosawa, 39°24'11"N, 133°12'33"E, 180 m alt., planted coniferous forest containing *Cryptomeria japonica* (Thunb. ex L.f.) D.Don, on soil, Jul 5 2019, *Hori 3281* (holotype MAK466765!, isotypes MBK!).

Diagnosis: Similar to *A.* ×*christensenianum* with blades two-pinnate pinnatifid in the middle, but once-pinnate pinnatifid in the upper part, and more shallowly serrated than *A.* ×*christensenianum*. $2n = 120$ (Figure 5), triploid.

Description: Terrestrial summer-green fern. *Rhizomes:* creeping, occasionally two-branched, stramineous, 5–15 cm long, 1.5–2.0 cm in diam., closely set with roots and persistent, densely clothed old stipe bases, glabrous; *fronds:* 2–5 per rhizome; *stipes:*

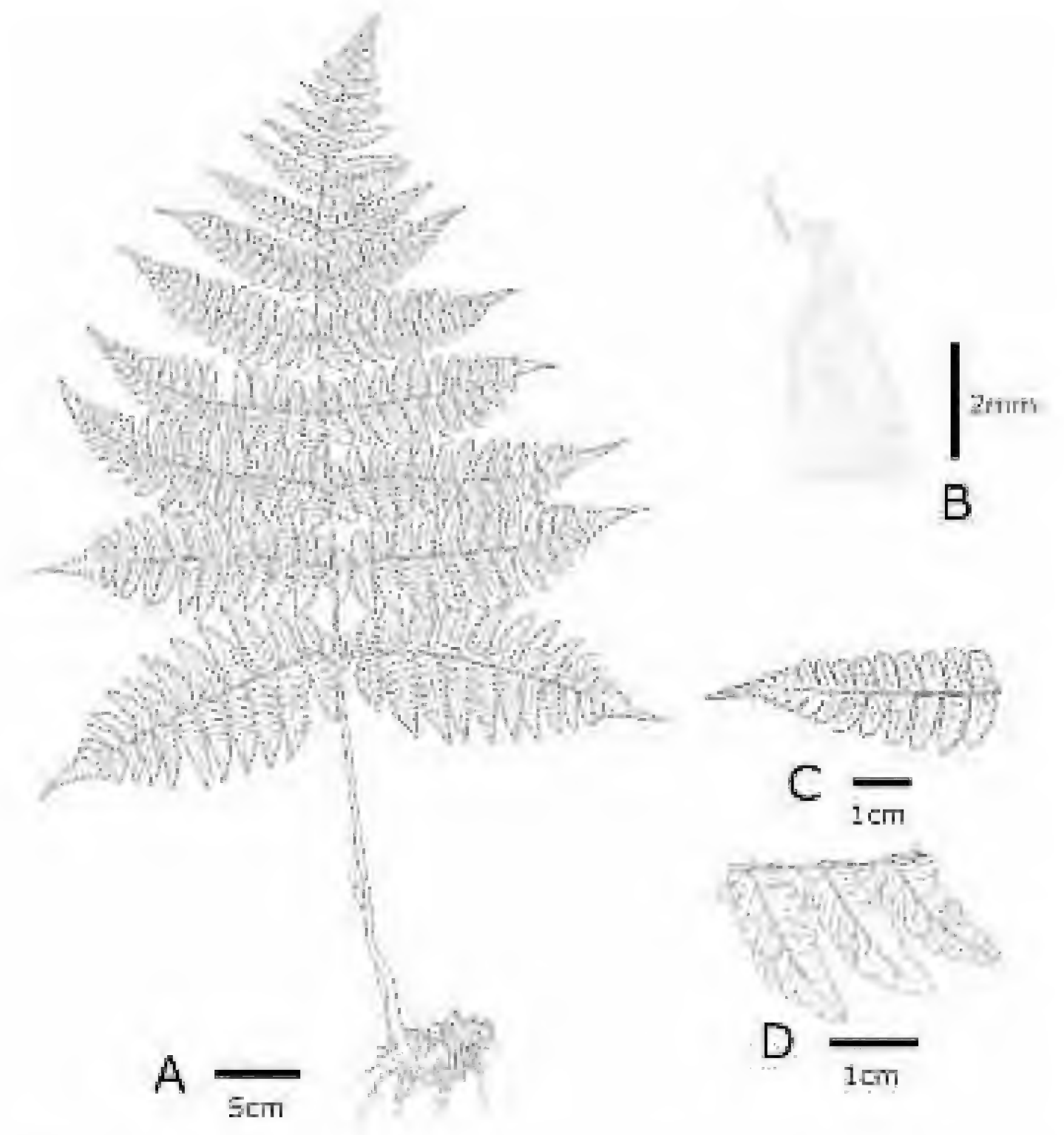

Figure 4. *Athyrium* ×*subchristensenianum* K.Hori. **A** habit, **B** lower stipe scale, **C** detail of abaxial pinnae, **D** detail of adaxial pinnae. **A-D** from the holotype (MAK466765) (illustration by K. Hori).

stramineous or slightly purple-red, 10–40 cm long, 0.3–0.5 cm in diam., sparsely clothed with stramineous to dark brown basal scales (3.0–6.0 mm long, 1.0–1.5 mm wide), lanceolate; *blades:* light green, two-pinnate pinnatifid or two-pinnate at the base and middle, one-pinnate pinnatifid at upper section, pinnatifid at the apex, 25–45 cm long, 25–40 cm wide, widely ovate; *rachises:* stramineous or slightly purple-red to dark brown, abaxially and densely pilose, several projections 0.1-mm long on the adaxial surface at the bases of costae; *pinnae:* 10–11 pairs, ascending, lanceolate, alternate, petioled (1–3 mm long), sessile near the apex, closely spaced or overlapping, lowest pinnae slightly reduced, second lowest pair usually largest, 10–20 cm long, 3–8 cm wide; *pinnules*: alternate, 10–14 pairs on the basal and middle sections of the blade, 8–10 pairs on the apex of the blade, reduced distally, ovate to lanceolate, serrated to lobed, vein-free, close to or reaching to the margin, 3–8 pairs in the middle lobe; *the most basiscopic pinnules on the lowest pinnae:* clearly short, independent from the costa, 0.5–1.0 cm long, 0.5–0.6 cm wide; *sori:* short linear- or V-shaped, 1.5–3.0 mm long, on the apex or middle of veinlets, 1–5 pairs per ultimate segment, exindusiate, somewhat persistent; *spores:* irregularly shaped, abortive. $2n = 120$, triploid. *Athyrium ×subchristensenianum* is a hybrid of *A. crenulatoserrulatum* and an unknown allotetraploid species (Hori 2020b).
Etymology: Similar to *A. ×christensenianum*.
Specimens examined: Japan. Honshu: Ishikawa pref., Kaga-shi, en route from Sosori-machi to Mt. Kariyasu-yama, ca. 50-100 m alt., 14 Jul 1989, coll. *S.Tsugaru et al. 12702* (TNS 566527, image!); Ibaraki pref., Hitachi-shi, Takasuzu-cho, 23 Nov 1981, coll. *N.Wada* (TNS 491015, image!); Tochigi pref., Kanuma-shi, Mt. Ozakusan, 8 Jul 2020, coll. *K.Hori 3403* (MAK 467068). Kyushu: Kagoshima pref., Okuchi-shi, Sakiyae, 18 Feb 1962, coll. *T.Yamanaka* (TNS 01101594, image!).
Distribution and Ecology: Found in Honshu and Kyushu, Japan, growing on soil under planted coniferous forest of *Cryptomeria japonica* at ca. 100-1000 m alt.

Key to the *A.* × *christensenianum* complex in Japan

1a Blades deltoid, yellowish green on adaxial surface ..... ***A. crenulatoserrulatum***
1b Blades widely or narrowly ovate, light green or dark green on adaxial surface 2
2a Blades dark green on adaxial surface 3
2b Blades light green on adaxial surface 4
3a Pinnae curved to the apex, the most basiscopic pinnules on the lowest pinnae not ... clearly short, decurrent into costa ..... ***A. decurrentialatum***
3b Pinnae ascending, the most basiscopic pinnules on the lowest pinnae clearly short, . independent from costa.....5
4a Blades 2-pinnate in the upper section ..... ***A. ×christensenianum***
4b Blades 1-pinnate pinnatifid in the upper section 6
5a Margin of pinnules shallowly serrated, spores regular shaped, fertile ***A. bipinnatum***
5b Margin of pinnules entire, spores irregular shaped, abortive ***A. ×pseudobipinnatum***
6a Blades narrowly ovate ..... ***A. ×decurrentiserratum***
6b Blades widely ovate ..... ***A. ×subchristensenianum***

DISCUSSION

These three new hybrids solve the complexity of the *Athyrium ×christensenianum* group (Figure 6). Park & Kato (2003) reported apogamous reproduction via the production of regular shaped fertile spores of *A. ×christensenianum*, Ebihara (2017) considered *A. ×christensenianum* retained its distribution by producing regular spores with

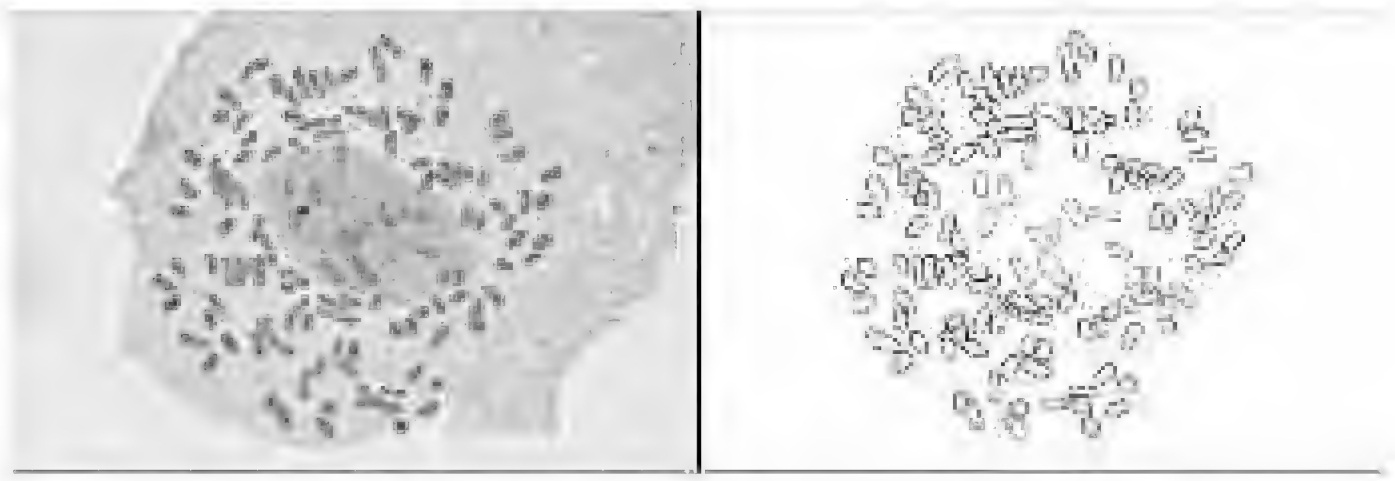

Figure 5. Photograph and sketch of mitotic chromosomes of *A.* ×*subchristensenianum* (MAK466765), 2*n*= 120.

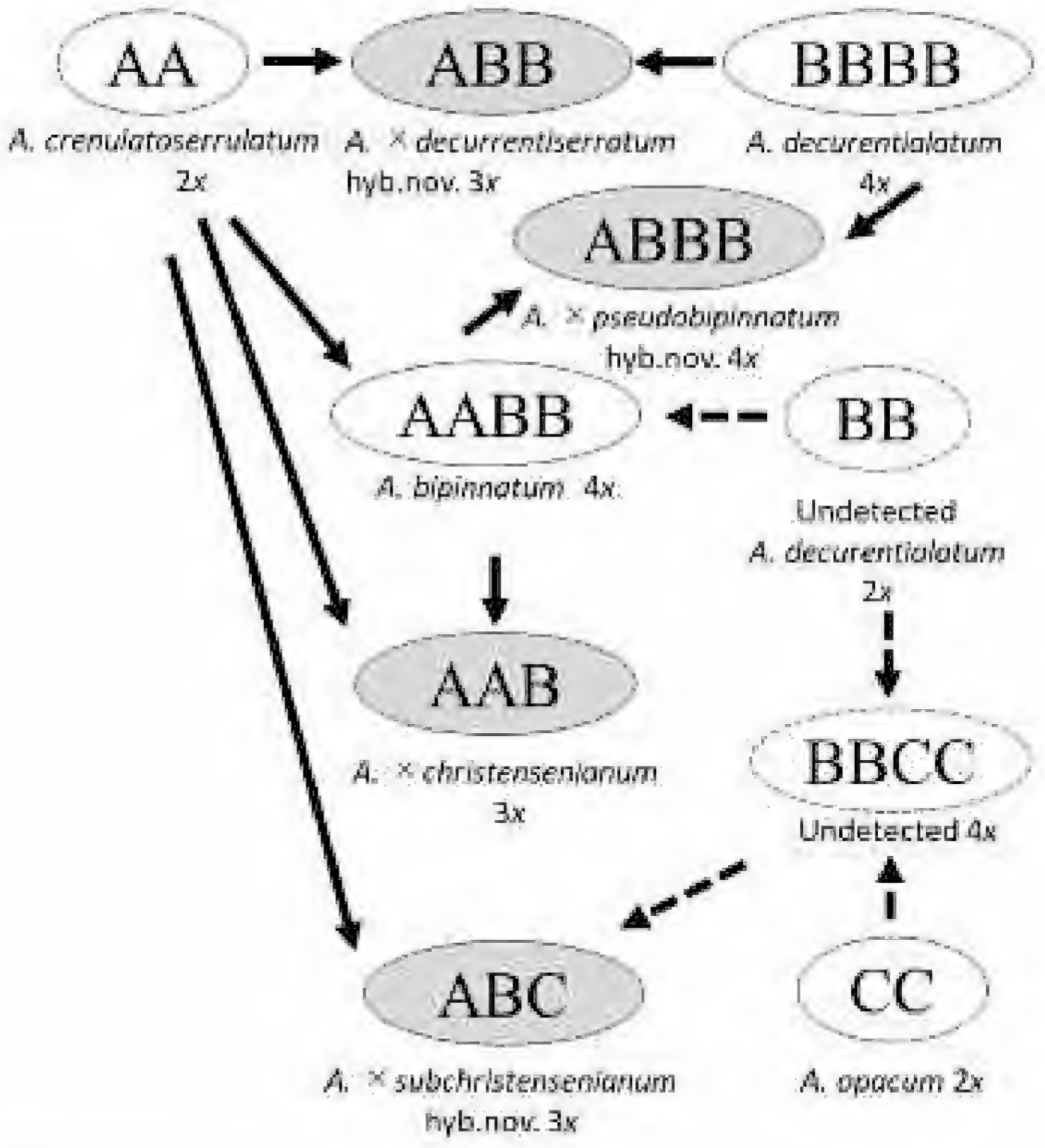

Figure 6. Relationships of new hybrids and its related species. White ellipses = species; gray ellipses = sterile hybrids; dashed white ellipses = undetected species; solid arrows = relationships between species; dashed arrows = relationships with undetected species.

apogamous reproduction. However, Ebihara (2017) mentioned there are continuous morphological variations between *A. decurrentialatum*, *A. ×christensenianum* and *A. crenulatoserrulatum*. Subsequently, Hori (2020a) described tetraploid sexual *A. bipinnatum*, rejecting the proposed hypothesis of apogamous reproduction of *A. ×christensenianum*. The new three hybrids in this study have shrunken sporangia and irregularly shaped spores, but their populations could be maintained or expanded by vegetative growth of the creeping rhizome. The morphological characteristics of these four hybrids and *A. bipinnatum* sometimes overlap, making identification difficult. *Athyrium bipinnatum* is the easiest to identify with its dark green blades and shallowly serrated pinnules; *A. ×pseudobipinnatum* is also readily identified by its dark green blades, shrunken sporangium, and irregularly shaped spores; The blade of *A. ×christensenianum* is two-pinnate pinnatifid in the middle to upper region. The serration of the pinnules of *A. ×christensenianum* is the deepest among the four hybrids, and is somewhat similar to *A. crenulatoserrulatum*. Distinguishing *A. ×subchristensenianum* and *A. ×decurrentiserratum* is the most difficult because the depth of serration of their pinnules and the colour of their blades are similar. However, the shape of the blades differs slightly between these two hybrids. The former has more widely ovate blades and latter has more narrowly ovate blades.

The relationship between *Athyrium opacum* and *A. ×subchristensenianum* should be noted. The morphological characteristics of *A. opacum* include an ascending rhizome and petioled pinnae (Ebihara, 2017). However, these are not reflected in *A. ×subchristensenianum,* although it has the genome of *A. opacum*. Furthermore, the origin of *A. ×subchristensenianum* is not completely solved because it assumes the existence of an unknown tetraploid sexual species that had its origin in a hybrid of *A. crenulatoserrulatum* and unknown diploid *A. decurrentialatum*; these should be the focus of future studies in the taxonomy of Japanese Cornopteroid ferns.

ACKNOWLEDGMENTS

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CHRISTENSENIA AESCULIFOLIA: ITS DIVERSITY, DISTRIBUTION, CONSERVATION STATUS AND MOLECULAR IDENTIFICATION FROM INDIA

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Keywords: DNA Barcode, endangered, Arunachal Pradesh, Assam, Meghalaya, *Kaulfussia*.

ABSTRACT

The fern genus *Christensenia* has been viewed as an ancient lineage, restricted to tropical forests of China and Indo-Malaysian regions. In India it is restricted to the North-East states, viz., Arunachal Pradesh, Assam and Meghalaya. The present communication deals with the taxonomy, diversity, distribution and conservation status of the species *C. aesculifolia* from India. Identification of this taxon is confirmed from India by morphological features and DNA sequencing.

INTRODUCTION

The marattioid fern genus *Christensenia* Maxon was earlier known as *Kaulfussia*, described by Blume (1828, p. 260) from Java. Subsequently, Griffith (1836) proposed a new generic name *Macrostoma* Griff., for the same fern; however, it was never validly published (Maxon, 1905, p. 3; Murdock, 2008, p. 744). Further, de Vriese and Harting (1853) accepted the generic name as *Kaulfussia* and recognised four species *viz*., *K. aesculifolia* Blume occurring in Malaysia and Philippines, *K. assamica* Griff., for North India, *K. korthalsiide* de Vriese for Sumatra and Philippines and *K. lobbiana* de Vriese (for Java). However, Baker (1874 pp. 444) rejected the species delimitation given by de Vriese and Harting (l.c.) and reduced the number of species to three i.e. *K. assamica*, *K. korthalsiide* and *K. aesculifolia* while *K. lobbiana* was treated as synonym of *K. aesculifolia*. Pteridologists of the 19th Century popularised the name *Kaulfussia* Blume but Maxon (1905, pp. 239-240), observed that the generic name *Kaulfussia* had already been given for a member of Asteraceae (Compositae) by Nees (1820), and on the basis of the principle of priority, the generic name *Kaulfussia* for fern genus was illegitimate. Hence, Maxon (1905) proposed a new generic name *Christensenia* with a single species (*C. aesculifolia*); the other species were merged, although it was recognised that variation occurred within the species. Subsequently, Christ (1907) described *C. cumingiana* from the Philippines. However, Copeland (1909) concluded that *C. aesculifolia* has a distribution from Malaysia to northern India while *C. cumingiana* was restricted to the Philippines. Christensen in 1938 (p. 528) merged *C. cumingiana* with *C. aesculifolia* and extended the distribution from North India, Java, Philippines and Sumatra. Ching (1940) proposed a new family Christenseniaceae for *Christensenia* and recognised two species, *C. aesculifolia* and *C. cumingiana*. This taxonomic delimitation was rejected by Holttum (1955, pp. 45-46). At the same time,

Ching (1959, pp. 65) described a new species, *C. assamica* (Griff.) Ching., from Assam, India. Subsequently other pteridologists (Braithwaite, 1977; Walker, 1979; Hill & Camus, 1986; Camus, 1990) studied other aspects of this genus and recognised a single species as *C. aesculifolia*. In 1993, Rolleri revised the genus and accepted two species *viz. C. lobbiana* (de Vriese) Rolleri and *C. aesculifolia* Blume (with two subspecies *viz.*, *C. aesculifolia* Blume subsp. *aesculifolia* and subsp. *korthalsii* (de Vriese) Rolleri). Rolleri et al. (1996) studied the spore ornamentation and confirmed the taxa mentioned in Rolleri's revisionary work. Thereafter, Murdock (2008) kept *Christensenia* within the family Marattiaceae as sister to a clade uniting *Marattia* Sw. and *Angiopteris* Hoffm. Recently, He and Christenhusz (2013) rejected the taxonomic treatment given by Rolleri (l.c.) and treated the genus as monotypic. However, PPG-I (2016) recognised it as a monophyletic but not a monotypic genus and included two species. Similarly, Fraser-Jenkins (2016) stated that *C. lobbiana* might be distinct from *C. aesculifolia*.

Two species of *Christensenia* have been documented from India. Dixit (1984) and Singh and Panigrahi (2005) reported the occurrence of *C. aesculifolia* from Arunachal Pradesh while Ching (1959) and Dixit (1984) documented *C. assamica* from Assam. However, Rolleri (1993) synonymised *C. assamica* under the name *C. aesculifolia* subsp. *korthalsii*. The taxonomic treatment of Rolleri (l.c.) was rejected by Fraser-Jenkins (2008 p. 26-27; 2016 p. 87-88), and retained the taxonomic treatment of Walker (1979) and Camus (1990), and excluded subspecies recognised by Rolleri (1993), as the un-patterned distribution, lack of cytological data and major morphological differences raised some concern about the validation of Rolleri's conclusions. Therefore, further investigation of this taxon is required.

In the present study plants of *Christensenia* were discovered and identified as *C. aesculifolia*, though showing great variation within the species. The taxon identity was confirmed by sequencing of genomic DNA and comparison with other species. Obtained sequences were also used to generate a barcode for the species.

MATERIALS AND METHODS

Christensenia aesculifolia was collected from the forest area of Itanagar (Arunachal Pradesh, India). A few individuals were pressed in field and samples were preserved in silica gel for molecular analysis. Morphological identification was carried out using available literature (Singh & Panigrahi, 2005; Fraser-Jenkins, 2008; 2016) and also confirmed by personal consultation with Prof. S. P. Khullar. Voucher specimens are deposited in BARO and ARUN herbaria. Molecular and phylogenetic analyses were performed and generated sequences were deposited in NCBI and BOLD data systems. The following methods were used for molecular and phylogenetic analysis.

DNA Isolation and PCR:

Fresh leaves weighing 50 mg were crushed in liquid nitrogen using a sterile mortar and pestle to obtain fine powder. DNA extraction was carried out using Plant/Fungi DNA isolation kit (Sigma Aldrich Cat# E5038). The PCR reactions were performed in a 20µl volume containing 1× final concentration of DreamTaq Green PCR Master mix (Cat# K1081), 50 ng of genomic DNA and 10 pmol of primers rbcLa-F and rbcLa-R (Levin et al., 2003; Kress & Erickson, 2007). PCR reactions were carried out under the following conditions: 94°C for 4 min, followed by 35 cycles of denaturation at 94°C for 30 sec, annealing at 54°C for 30 sec and extension at 72°C for 1:30 min., with a final extension at 72°C for 10 min and stored at 4°C.The PCR product was visualized on 2% agarose gel and amplified PCR product was purified using PurelinkTM Quick PCR Purification

kit (Cat# K310001) and sequenced at Eurofins Genomics India Pvt Ltd., Bangalore.

Phylogenetic analyses

The phylogenetic tree was generated using *rbcL* sequence data of *Christensenia aesculifolia* with other related material of Marattiaceae obtained from GenBank (Table 1). Sequence ambiguities were edited by aligning the forward and reverse sequence in Bioedit ver.7.2.5 (Hall, 1999). Multiple sequence alignment was carried out by using Clustal X (Thompson et al., 1997). Nucleotide substitution models that best fit for phylogenetic analysis were determined by using jModelTest (Darriba et al., 2012) with models selected based on the Akaike Information Criterion (AIC). Phylogenetic tree was obtained based on Maximum likelihood (ML) method analysis in PAUP* ver.4.0 (Swofford, 2002) with GTR+I+G model of nucleotide substitution using a heuristic algorithm with random addition of sequences (10 replicates) and tree-bisection reconnection branch swapping (TBR). The same settings were used for bootstrap analysis with 1000 replicates. All positions containing gaps and missing data were eliminated during construction of phylogenetic tree.

RESULTS AND DISCUSSION

The highly distinctive and ancient fern *Christensenia aesculifolia* was found by us recently in Arunachal Pradesh. Morphologically, the species shows great variation in height, nature of the stipe (sparsely or densely papillose), frond (simple, trifoliate, pentafoliate), shape of lamina (lanceolate-ovate or rhomboid), nature of pinnae (herbaceous-subcoriaceous or coriaceous), number of sporangia per synangia and trichome structure. The detailed taxonomy, diversity, distribution and conservation status from India is given (Figure 1). Genomic sequencing was carried out to generate the sequences and generated sequences are blast with NCBI data. Based on this comparison of the DNA sequence data with related taxa, the phylograph was generated to confirm the identity of the species (Figure 2). After confirmation of species the DNA barcode was generated.

Taxonomic Treatment

Christensenia aesculifolia (Blume) Maxon Proc. Biol. Soc. Washington 18: 240. 1905.
Kaulfussia aesculifolia (Blume) Blume, Enum. P1. Javae 2:260. 1828.
Aspidium aesculifolium Blume, Enum. P1. Javae 2:143. 1828.
Kaulfussia korthalsii de Vriese, Nederl. Kruidk. Arch. 3. 186. 1852.
Christensenia aesculifolia subsp. *korthalsii* (de Vriese) Rolleri, Amer. Fern J. 83(1): 16. 1993.
Kaulfussia assamica Griff., Asiat. Res. 19: 108–109, t. 18. 1836.
Christensenia assamica (Griff.) Ching, Act. Phytotax. Sinica 7(3): 213. 1958.
Type: Indonesia, Java, C. L. von Blume, L.

Plant terrestrial, 10–60 cm in height; *rhizome* 1-2 mm thick, long creeping, branched, scaly, fleshy, rough due to presence of leaf scars with many fibrous roots arises at base only; *scales* 8–10 mm long, 1–3 mm broad, bicolorous with red dots, apex obtuse-acute, margin undulate, base round; *fronds* 29–58 cm long, 5–10 cm broad, monomorphic; *stipe* 18–35 cm long, scaly at base, fleshy, green, papillose (densely or sparsely), grooved; *lamina* 11–23 cm long, 5–10 cm broad, ovate-lanceolate or rhomboid, thick, fleshy, dark green, smooth, upper surface, faint rough lower surface; *pinnae* 1–4 (up to 5), upper pinnae lobed, ovate-lanceolate (sometime rhomboid), densely papillose on lower side, upper side smooth, apex acute-acuminate, margin entire-undulate, costa prominent; *veins*

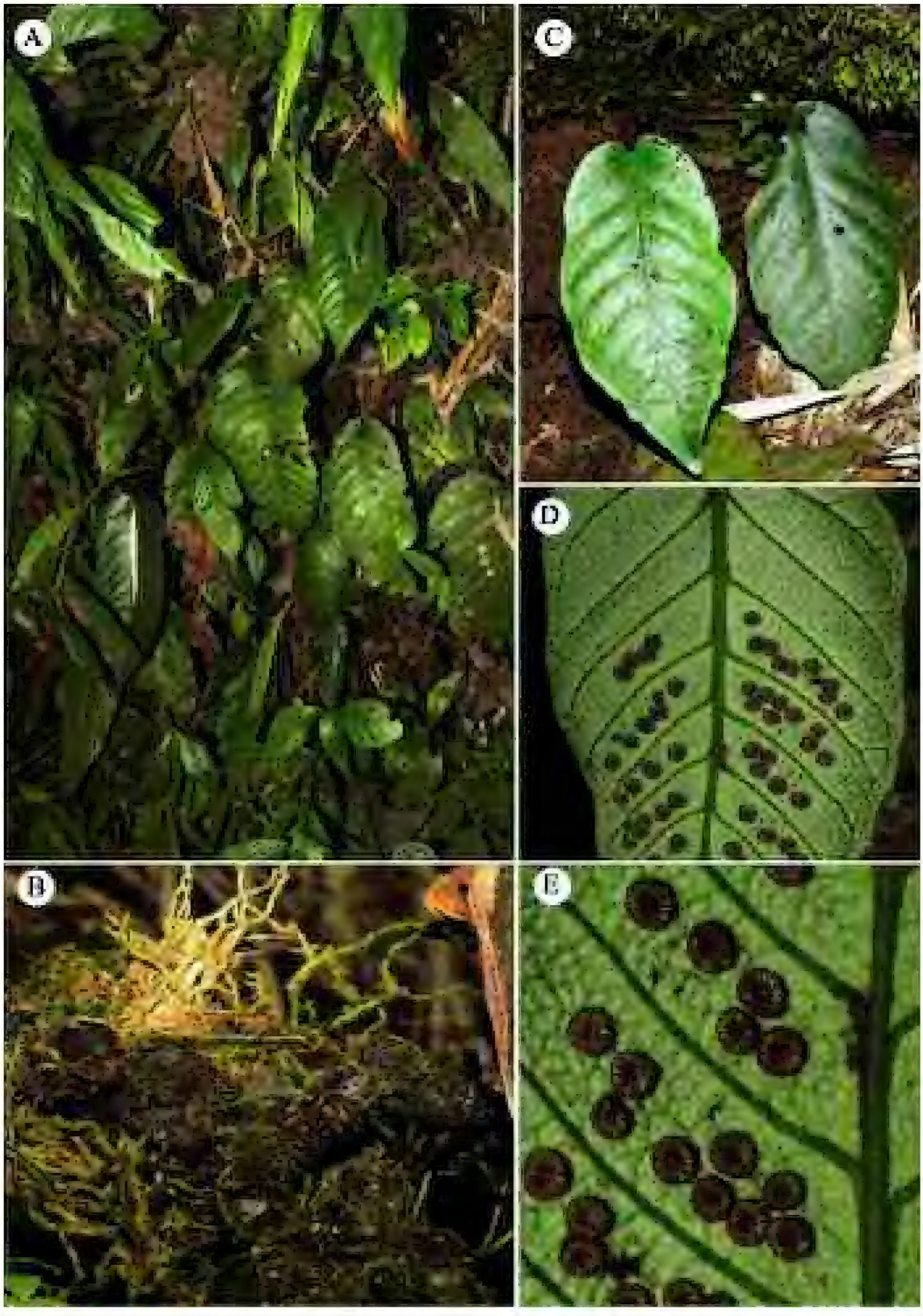

Figure. 1. *Christensenia aesculifolia*: A. Habit; B. enlarged rhizome; C. upper surface of pinna D. lower surface of pinnae with synangia; E. enlarged view of synangia.

reticulate, visible on lower surface; *synangia* > 40 per frond, 2–5 mm in diameter, green at young, brown-black at maturity, orbicular, consists of 12–18 (up to 22) fused sporangia per synangia; *spores* 50–58 µm in diameter, monolete, elliptic-circular in distil view, exine pointed.

Distribution: World – China, Indonesia, India, Malaysia, Myanmar, Sumatra, Thailand, Vietnam.

INDIA: Arunachal Pradesh, Assam, Meghalaya.

Phenology: Vegetative Phase – July-October, Reproductive Phase – November-February

Conservation Status: *Christensenia aesculifolia* is a rare fern in Arunachal Pradesh, Assam and Meghalaya states of India. About 50–80 individuals were found at Itanagar. The Area of Occupancy (AOO) is 200–350 km^2 however, the population size is small. Hence, at present according to IUCN (2020) criteria, currently this species is considered Endangered (EN).

Note: It grows on hill slopes at an altitude of 400-500 m, together with *Blechnum orientale* L., *Lycopodiella cernua* (L.) Pic.Serm., *Pteris biaurita* L., *P. pseudopellucida* Ching, *Tectaria heterocarpa* (Bedd.) C.V.Morton and *T. subconfluens* (Bedd.) Ching.

Specimen Examined: India, Arunachal Pradesh, Papumpare dt., Itanagar to Naharlagun road, along cut edges of hills, 400-500 m alt., 17/02/2018, S. M. Patil & K. S. Rajput-3037 (BARO12345700102); 5 km from Chimpoo, 03/08/1994, G. D. Pal-6704 (ARUN#); Subansiri dt., 1 Km from N. e. of Ziro Point, 22/12/1978, G. D. Pal-70347 (ARUN#)

Molecular identification, DNA barcoding and phylogenetic analyses

The generated nucleotide sequence was used for a BLAST search in the GenBank database (www.ncbi.nlm.nih.gov) for identification of the species. Confirmation was done by 99% base pair match of the sequence obtained to the closest available reference sequences (Leung et al., 1991) i.e. *Christensenia aesculifolia* (Accession#EU439079)

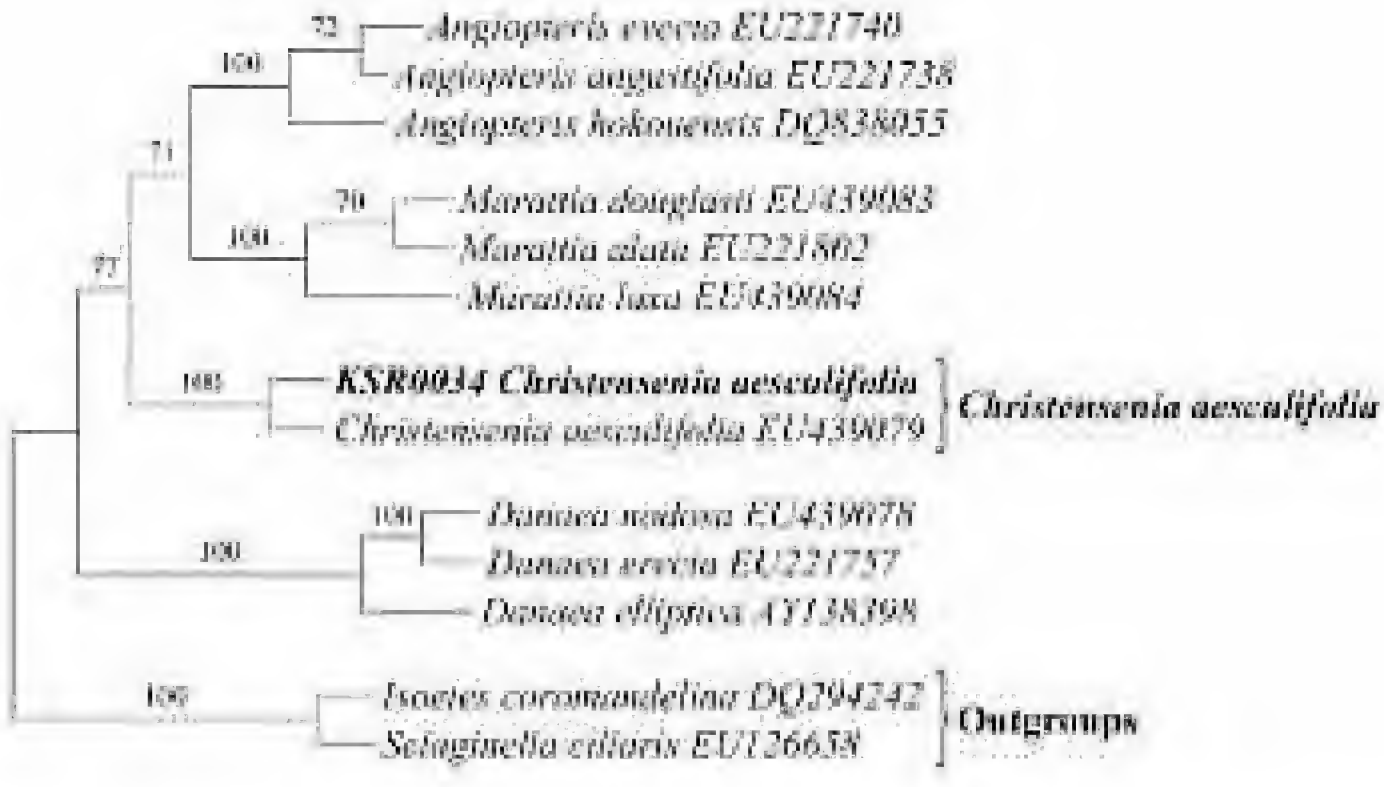

Figure 2: Maximum likelihood (ML) cladogram generated from *rbcL* dataset for *Christensenia aesculifolia* and other related taxa. *Isoetes coromandelina* and *Selaginella ciliaris* were used as outgroup. Bootstrap values are indicated on the tree branches.

submitted by Murdock, A. G. (2008). After molecular identification, morphological characteristics were compared with the available literature for the further confirmation of the identity. Nucleotide sequence of *Christensenia aesculifolia* was submitted to NCBI (accession number MK603020) and to BOLD to generate DNA barcode (BOLD ID KSR-0034). Phylogenetic analyses shows 100% bootstrap support based on the *rbcL* dataset of the sample KSR-0034 with *C. aesculifolia* from Malaysia (Murdock, 2008) (Figure 2).

Conclusion: The identity of *C. aesculifolia* was confirmed by the conventional as well as molecular methods. The present study also confirms the variation within the species documented earlier i.e. *stipe* densely or sparsely hairy, *fronds* simple (having 1-3 pinnae rarely 5) or palmate, *lamina* lanceolate-ovate to rhomboid with lobed or unlobed margins, herbaceous-subcoriaceous or coriaceous, *veins* and *lamina* surface (lower) papillose-trichomatose or glabrous.

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TAXONOMIC NOTE ON THE GENUS *MARSILEA* (MARSILEACEAE) IN THAILAND

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Keywords: Water Clover, *Marsilea*, SE Asia, Thailand.

ABSTRACT

A review of the taxonomy of the genus *Marsilea* in Thailand is presented. Two indigenous species represent the genus: *Marsilea minuta* L., *M. scalaripes* D.M. Johnson, and two introduced species: *M. drummondii* A. Braun, *M. mutica* Mett. A key to species based on Thai specimens, together with the descriptions and illustrations, are provided. The taxonomic status of *Marsilea* in Cambodia, Laos PDR, and Vietnam is discussed.

INTRODUCTION

Marsilea L. (Marsileaceae) is a genus of about 55 heterosporous aquatic fern species, naturally occurring in tropical and temperate regions (Jones, 1998; PPG1, 2016; Short, 2011). The genus was named after Italian naturalist Count Luigi Marsili (1656–1730) (Johnson, 1993). These aquatic ferns tend to be invasive in both aquatic and marshy habitats; however, they are difficult to identify at the species level due to the lack of diagnostic characteristics from sterile specimens, resulting in unresolved taxonomic problems (Whitten and Jacono, 2013). Two ecological types were observed: 1) obligate aquatic species having glabrous leaves that reside in permanent water bodies, and 2) facultative aquatic species having pubescent leaves that prefer fluctuating wetland habitats and survive throughout seasonal limits in wet and dry periods. In many countries, native people use the fronds as vegetables and herbs (Kosaka et al., 2006; 2013; Sarker & Hossain, 2009; PROSEA, 2016).

Although only one common and widespread species, *M. crenata* C.Presl, was reported in the Flora of Thailand (Tagawa and Iwasuki, 1989), other populations of *Marsilea* in Thailand have uncertain identities. Based on traditional identification, sporocarp morphology is an important character; however, sporocarps are frequently absent in field populations. The absence of fertile specimens makes identification uncertain. Moreover, there is some inconsistency in determinations of Thai *Marsilea*; for example, Holm et al. (1979) and Waterhouse (1993) reported *M. quadrifolia* L., a native plant of Europe, in Thailand. Also, *M. minuta* L. is reported as native to Thailand (Beentje, 2017; CABI, 2019). Additionally, Johnson (1988) described *Marsilea scalaripes* as a new species of *Marsilea* section *Clemys* from the Malay Peninsula. However, these species were not recognized as being in Thailand when described in those publications outlined above. Therefore, the objective of this study is to provide tentative identifications, plus descriptions and illustrations, of those species that are currently found in Thailand.

MATERIALS AND METHODS

Plant specimens were collected throughout Thailand during 2014 and 2020 in different seasons. Some of the collected plants were transplanted in 35 × 45 × 15 cm pots at the Plant Protection Research and Development Office, Department of Agriculture, Ministry of Agriculture and Cooperatives, Bangkok, to get sporocarps and to conduct growth comparisons. Other plants were prepared as dry herbarium specimens to be included as voucher specimens that are later identified and deposited at the Professor Kasin Suvatabhandhu Herbarium, Botany Department, Faculty of Science, Chulalongkorn University, Thailand [BCU]. The collected specimens were compared with dried herbarium specimens from BCU, BK, BKF, BM, BRI, FLAS, K, P, L, and SING together with digitized specimen images of *Marsilea* available on the web pages of each herbarium. Thiers (2020, continuously updated) was followed in this article for herbarium acronyms.

RESULTS

Marsilea Linnaeus, Sp. Pl. 2 (1753): 1099; Gen. Pl. ed. 5 (1754): 485.
Type: *Marsilea quadrifolia* L.
Plants aquatic or amphibious. Rhizome like stolon, submerged, long creeping, irregularly branching, forming dense colonies; roots rising at the nodes, and sometimes on internodes. Stipe filiform, stiffly erect, or procumbent in land leaves, lax in floating leaves. Frond slightly palmately compound with four leaflets, heteromorphic, floating leaves averaging larger than land leaves. Pinnae were obtriangular to fan-shaped, cuneate or obdeltate, pulvinate at base, frequently with numerous red or brown streaks abaxially in floating leaves. Sporocarps borne on branched or unbranched stalks at or near base of stipe, above ground, attached laterally to stalk apex, tip of stalk often protruding as a tooth; sporocarps glabrous or densely to sparsely hairy, less so with age, dehiscing into two valves.
The genus consists of ca. 55 species that are widely distributed in temperate and tropical regions with centres of diversity in tropical Africa and Australia (Johnson, 1993; Jones, 1998). Four species, two native and two introduced plants are recognized here.

KEY TO SPECIES IN THAILAND

1a. Stolon with internodes up to 10 cm long, producing clumps of fronds; lamina bearing densely villose hair, greyish-green ..... ***M. drummondii***
1b. Stolon with internodes usually up to 5(–10) cm long, producing solitary fronds; lamina glabrous, light to dark green 2
2a. Lamina two-toned green with reddish-brown stripes that split the darker green on the top half of the leaflets and the lower half a lighter green; sporocarps solitary ..... ***M. mutica***
2b. Plant not as above; sporocarps in groups, up to 10 3
3a. Sporocarps 3–5, with basal teeth, clumped at stipe base ..... ***M. minuta***
3b. Sporocarps 2–12,without basal teeth, lined upward on the lower half of stipe..... ***M. scalaripes***

1. *Marsilea drummondii* A.Braun, Linnaea 25 (1852): 72. — *Zaluzianskia drummondii* (A.Braun) Kuntze, Revis. Gen. Pl. 2 (1891): 823. Type: Australia: (Western Australia) Swan River, 1839, *Drummond s.n.* (K001092640) [K].
Rhizome much-branched, bearing densely brownish scales towards the tips, with

internodes up to 10 cm long. Fronds up to 35 cm long, solitary. Stipes rather sparse, green to stramineous, 15–35 cm long, scaly. Leaflets broadly cuneate or fan-shaped, apex round and subentire or crenate to undulate, base broadly cuneate, 10–25 mm long, 15–30 mm wide, greyish-green, bearing dense villose hairs. Sporocarps in groups of 2(– 4); stalks 10–50 mm long, attached at stipe base, unbranched, glabrous to sparsely scaly; conceptacles oblong, laterally flattened, 5–10 mm long, brown to black, densely hairs and scaly, faintly to distinctly ribbed; upper surface convex; toothed near the junction with the stalk, upper basal tooth and lower basal tooth short, obtuse (Figure 1).

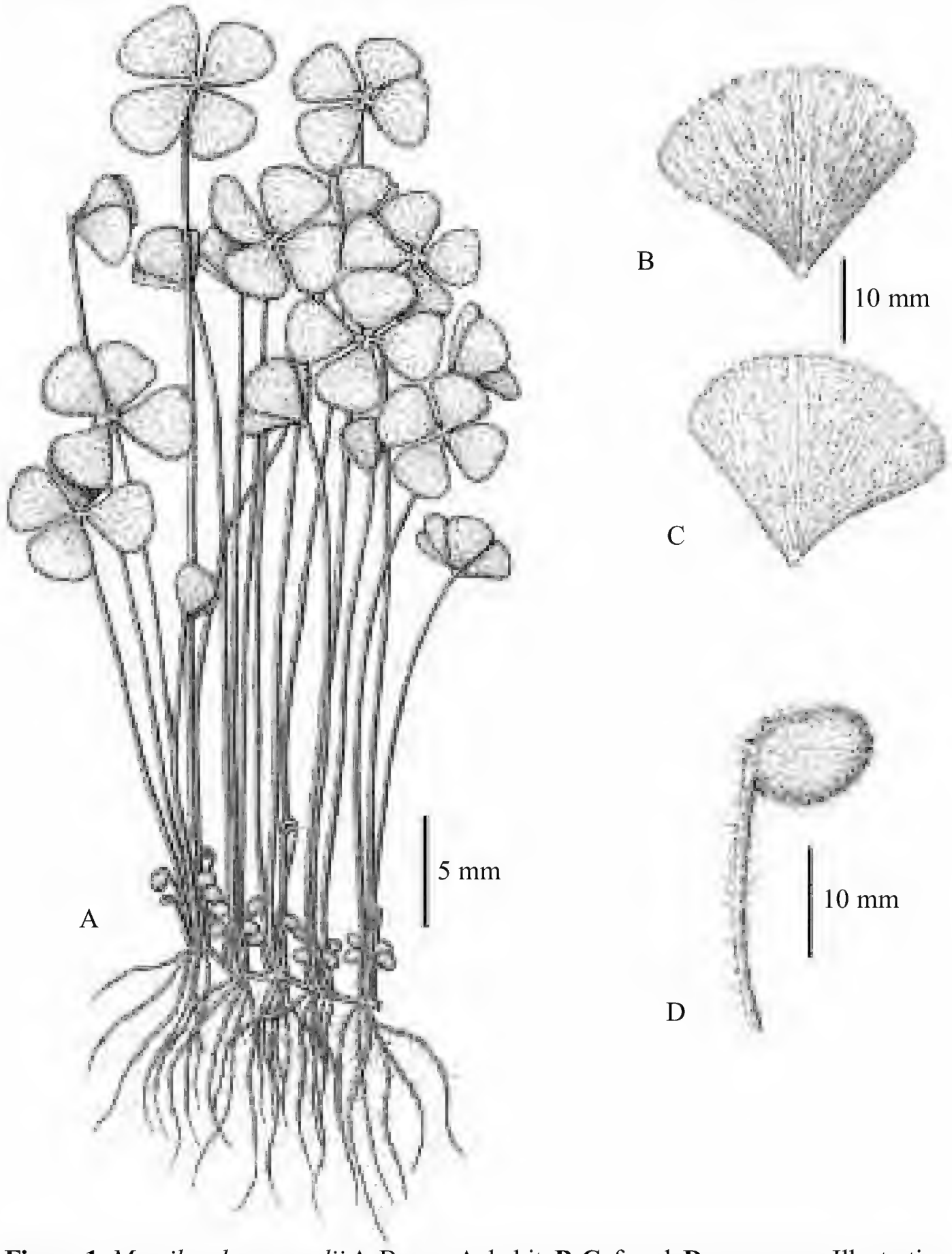

Figure 1. *Marsilea drummondii* A. Braun. **A**. habit. **B-C**. frond. **D.** sporocarp. Illustration by Wilawan Nuchthongmuang from *Petchsri et al. 1* (BCU).

Distribution: Endemic to inland areas of Australia.
Grows in shallow still or sluggishly moving water. Introduced into Thailand as ornamental plants where, up to now, it has not been found in natural habitats.
Representative specimens examined: **THAILAND**: BANGKOK, 26 July, 2012, *AR. s.n.* [BCU]; Bangkok, 30 October 2016, *Petchsri et al. 1* [BCU]; **AUSTRALIA**: Donald's Plain, 75 miles west of Cobar, 27 October 1963, *Constable 4635 A* [L]; Narrabri, Lagoon Creek, 18 November 1976, *Coveny & Roy 8712* [L]; Berri (ca. 200 km north-east of Adelaide), on the south-east side of the Murray River, 11 April 1956, *Eichler 12360* [L]; Narrandera, Wah Wah creek on the eastern side of Bringagee road, 23 January 1980, *Denny 421* [L].

2. *Marsilea minuta* L., Mant. Pl. Altera [2] (1771): 308. Type: India, *Anon s.n.* (LINN-HL1254-6) [lectotype LINN!].
Marsilea crenata C.Presl, Reliq. Haenk. 1 (1825): 84. Type: Borneo, 1865, *Lowe s.n.* (K000570754) [holotype K!].
Marsilea sinensis Hand.-Mazz., Symb. Sin. 6 (1929): 47. Type: China, Sichuan, 25 March 1914, *Handel-Mazzetti, H.F.v. 914* (K001092577) [isotype K!].
Rhizome much-branched, bearing pale brown hairs and scaly towards the tips, with internode up to 5 cm long. Fronds up to 20 cm long, solitary. Stipes rather close, green to stramineous, pale brown or darker towards base, 10–20 cm long, glabrous, or sparsely scaly. Leaflets broadly cuneate or fan-shaped, apex round and subentire to crenate, base broadly cuneate, 10–15 mm long and almost as wide, light green, glabrous or sparsely scaly or hairy at margin when young. Sporocarps in groups of 2–3(–5) on short stalks, stalks 5–7 mm long, attached at stipe base, unbranched, glabrous to sparsely scaly; conceptacles oblong, laterally flattened, 3–5 mm long, brown to black, covered with caducous hairs and scaly when young, usually quite glabrous when mature, not ribbed; upper surface convex; toothed near the junction with the stalk, upper basal tooth and lower basal tooth short, obtuse (Figure 2).
Distribution: Old World tropics and subtropics; introduced into the United States, Trinidad & Tobago and Brazil.
Grows in shallow water and drying mud in open areas range from sea level to 1,350 m alt.
Representative specimens examined: **THAILAND**: CHIANG RAI, 7.5 km west of Highway No.1 on road No.1149 to Wat Doi Tung, 940 m, 8 February 1984, *Anderson 5410* [BKF]; Mueang District, 400 m, 24 January 1881, *Paisooksantivatana 560-81*[BK]; KANCHANABURI, Sai Yok District, 150 m, 25 November 1971, *van Beusekom et al. 3968* [BKF; L, P]; Srisawat District, Erawan National Park, 520 m, 5 September 2007, *Thitimetharoch & Faden 751* [BKF]; NONG KHAI, Bueng Karn District, 200 m, 17 October 1993, *Boonkerd 1271* [BCU]; BANGKOK, 20 m, 1 November 1977, *Boonkerd s.n.* [BCU]; Plant Protection Research and Development Office, 30 April 2007, *Boonkerd 1871* [BCU]; Bang Khen, in the canal along the highway, 13 November 1965, *Iwatsuki et al. T–239* [BKF]; 22 January 1920, *Kerr 3944* [BK]; 15 March 1935, *Winit s.n.* [BKF]; CHANTHABURI, Pong Nam Ron District, 3 July 1994, *Chokchuapattanakit 45* [BCU]; NAKHON SRI THAMMARAT, 8 August 1991, *Damsri 36* [BCU]; KRABI, Khao Phanom District, 100 m, 24 March 1930, *Kerr 18657* [BK]; RATCHABURI, Ban Pong District, Huai Yang, 50 m, 14 August 1966, *Larsen et al. 1593* [BKF]; SARABURI, Mueag District, 75 m, 19 November 1973, *Maxwell 73-652* [BK]; CHIANG MAI, on the road from Sop Aep to Pha Mewn (Ban Yang), 700 m, 1 October 1971, *Murata et al.*

T–15575 [BKF; P]; Ban Yang at middle elevation of Doi Inthanon, 600–1350 m, 17 December 1965, *Tagawa et al. 2422* [BKF]; PHITSANULOK, Bang Rakam District, 120 m, 27 July 1973, *Murata et al. T–17249* [BKF; L]; SAKON NAKHON, Nong Han, 250 m, 9 December 1973, *Na-Thalang s.n.* [BCU]; Phuphan National Park, 12 November 1984, *Murata et al. T–51315* [BKF]; LOEI, Mueang District, 240 m, 26 December 2011, *Norsaeng & Tathana 8503* [QBG]; PHATTALUNG, Mueang District, 30January 2000, *Ritthisunthorn 67* [PSU]; PHETCHABUN, Wichian Buri District, 27 July 1973, *Pengkai & Fukuoka T–17849* [BKF]; YALA, Tanto District, 15 December 1986, *Supapol 224* [PSU]; KHON KAEN, Chum Phae District, 2 September 1967, *Shimisu et al. T–8684* [BKF; P]; CHAI NAT, Chao Phraya Dam, 150 m, 5 march 1958, *Smitinand 4459* [BKF]; NAKHON RATCHASIMA, Pak Chong District, Chanthuek, 200 m, 15 march 1958, *Smitinand 4459* [BKF]; SONGKHLA, Ratthaphum District, 15 January 1999, *Sangtam 8* [PSU]; SISAKET, Kanthararom District, 4 June 1951, *Tem & Ploenchit 5419* [BKF]. **INDONESIA**: SUMATRA, N. Sumatra Island, 21 January 1929, *Lörzing 15055* [L]; JAVA, North van Bogor, 240 m, 1 February 1950, *van Ooststroom 12657* [L]. **THE PHILIPPINES**: LUZON, Ilocos Norte, 1907, *Mearns 2317* [P]; MINDANAO, Davao

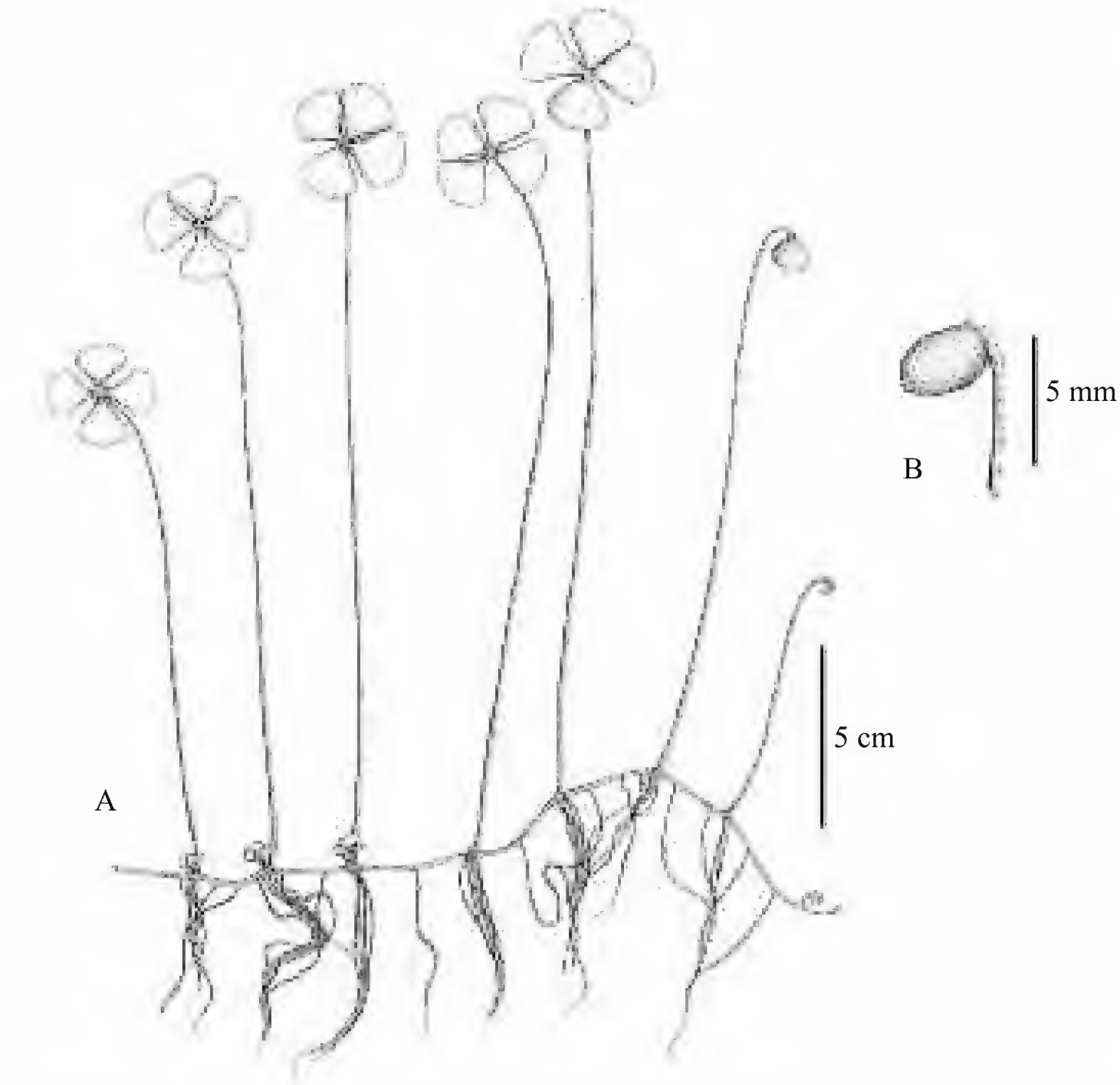

Figure 2. *Marsilea minuta* L. **A.** habit. **B.** mature sporocarp. Illustration by Wilawan Nuchthongmuang from *T. Boonkerd 1871* (BCU).

District, March 1904, *Copeland 462* [P]. **AUSTRALIA**: QUEENSLAND, Cook, Rutland Plains, S of Kowanyama, 24 July 2000, *Fensham 4051* [BRI]; Cook, Soda Spring, Strathburn, 14 September 2003, *Fensham 4941* [BRI]; North Kennedy, Earlando Beach, 28 km of Airlie Beach, 13 September 1992, *Batianoff 9209348* [BRI]; South Kennedy, 8 km S of Midge Point, Tonga Range, 60 m, 25 June 1994, *Batianoff and Price 940641* [BRI]. **THE UNITED STATES**: FLORIDA, Miami-Dade County, Holiday Hammock Preserve, 21 December 2007, *Bradley s.n.* [FLAS]; Alachua County, Gainesville, 26 December 2011, *Lange & Abbott 1334* [FLAS].

3. *Marsilea mutica* Mett., Ann. Sci. Nat. Bot., sér. 4, 15 (1861): 88. — *Zaluzianskia mutica* (Mett.) Kuntze, Revis. Gen. Pl. 2 (1891): 823. Type: New Caledonia, in loeis inundatis prope [Bayap], *Vieillard 1698* (K001092629) [K, P].
Rhizome much-branched, virtually glabrous except for a few hairs sometimes present towards the tips, with internodes up to 5 cm long. Fronds up to 25 cm long, solitary. Stipes rather sparse, green to stramineous, 15–25 cm long, glabrous. Leaflets broadly obovate to broadly cuneate or fan-shaped, apex round and entire, base broadly cuneate, 20–30 mm long, 15–25 mm wide, upper side green distally, yellow-green proximally, separated by a brown zone, pale green to stramineous throughout underneath, glabrous. Sporocarps solitary (or rarely in groups of 2– 4); stalks 10–50 mm long, attached at stipe base, unbranched, glabrous; conceptacles ellipsoid to globose, 3.5–5 mm long, brown to black, glabrous, distinctly ribbed; upper surface convex; basal teeth absent (Figure 3).
Distribution: Australia and New Caledonia; introduced into Thailand, New Zealand and the United States.
Commonly grown as an aquatic plant in ponds. Introduced into Thailand as ornamental plants. The aquatic form is larger than those on drying mud and nearly glabrous. So far, *M. mutica* has not been found in natural habitats.
Representative specimens examined: **THAILAND**: BANGKOK, 30 October 2016, *Petchsri et al. 2* [BCU]. **NEW CALEDONIA**, Ponds located near the Pont des Français, August 1869, *Balansa 1532* [P]; Nouméa, 15 February 1909, *Franc 1323* [P]. **AUSTRALIA**: CANBERA, Sullivan's Creek, 28 December 1972, *Pulley 1218* [L]; Macquarie Fields - Glenfield Railway Line, 27 December 1963, *Tindale & McBarron 8629* [L]. **UNITED STATES**: ALABAMA, Marion County, 19 November 2002, *Jacono 502* [FLAS]; Marion County, Hamilton, 13 August 2001, *Greene s.n.* [FLAS].

4. *Marsilea scalaripes* D.M.Johnson, Am. Fern. J. 78(2), fig. 1: 69 (1988); 68. Type: Malaysia, *Corner S.F.N. 38190* [holotype SING, fragment BM].
Rhizome irregularly branching, bearing pale brown to stramineous hairs, densely pubescent at the tips, with internode up to 10 cm long. Fronds up to 15 cm long, solitary. Stipes rather sparse, green to stramineous or pale brown, darker towards base, 10–15 cm long, glabrescent to glabrous. Leaflets broadly obovate to broadly cuneate, apex round and subentire, base broadly cuneate, 14–16 mm long, 12–14 mm wide, often streaked with brown false veins between the true veins on the lower surface, glabrous, with hydropoten uniformly distributed abaxially. Sporocarps in groups of 2–9(–12) on short stalks, stalks 4–8 mm long, attached above stipe base, lined upward on the lower half of stipe, unbranched, glabrous to scaly; conceptacles ovoid to ellipsoid, 3–4.5 mm long, dark brown, thinly covered with matted hairs, ribbed; upper surface concave; basal teeth absent (Figure 4).
Distribution: Cambodia, Peninsular Malaysia, Thailand (Figure 5).

Grows in flowing shallow water bodies at low altitude.
Representative specimens examined: **Thailand**: BANGKOK, Plant Protection Research and Development Office, 30 April 2007, *Boonkerd 1870* [BCU]; NAKHON NAYOK, along the roadside to Pak Praek at ca. 146.5 km, 31 January 1975, *Chermsirivathana & Prayad 2024* [BK]; CHON BURI, along the roadside from Rayong to Chantaburi, 22 December 1973, *Na-Thalang s.n.* [BCU]; NAKHON PHANOM, Na Wa District, 11 October 2010, *Zungsontiporn et al. 2189* [BCU]; PRACHIN BURI, Prachantakham District, 6 September 2011, *Zungsontiporn et al. 885, 886* [BCU]; **Cambodia**: SIEMREAP, Baray, 1 December 1997, *Hul et al.540* [P]

DISCUSSION

Water Clovers are familiar as common weeds in Thailand and are found throughout the country. They can endure drought well, so they can also be found on drying mud. Based on previous descriptions in the Flora of Thailand, all the native plant specimens have been determined as *M. crenata* C.Presl (Tagawa & Iwasuki, 1989). However, we treat

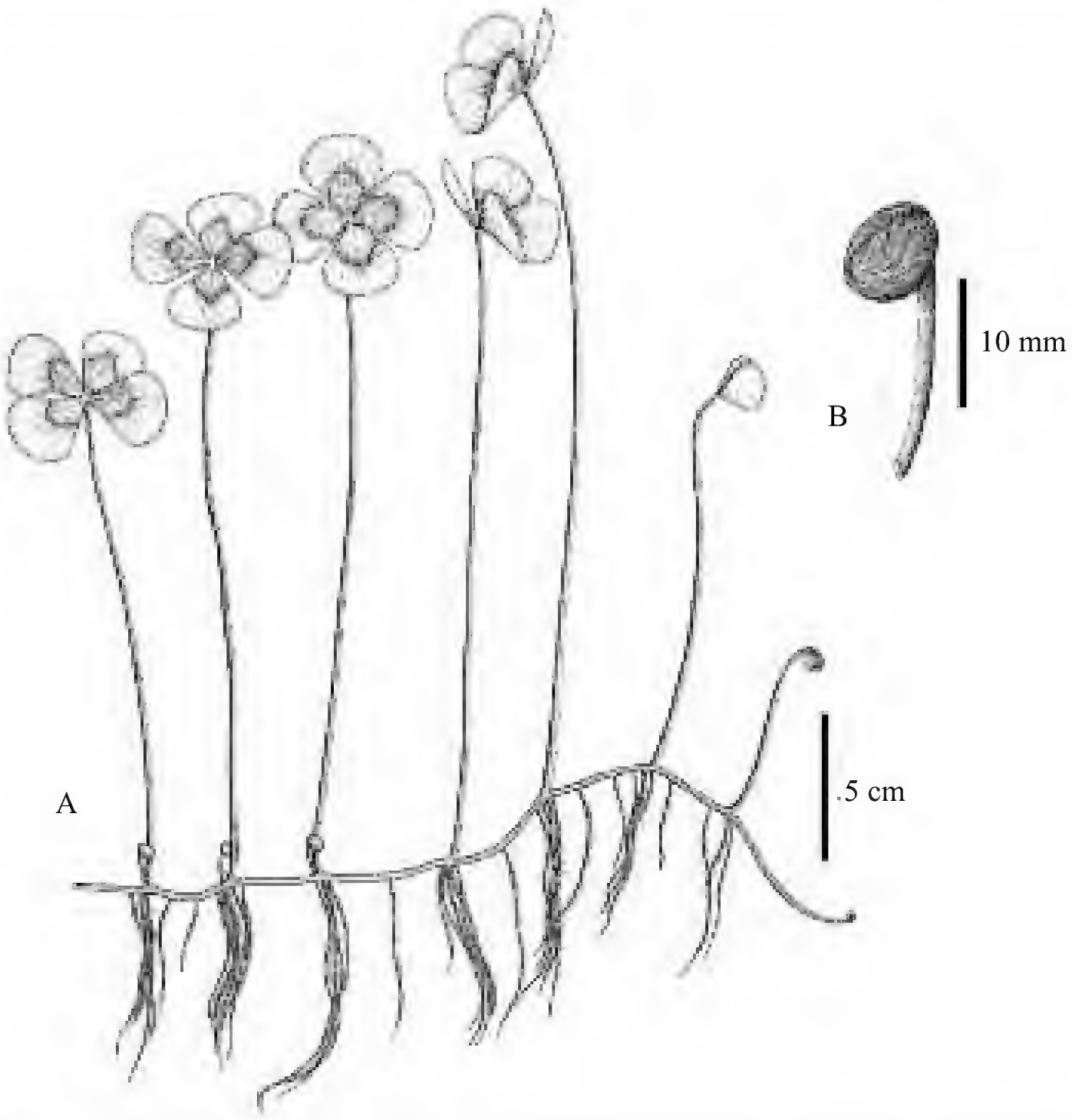

Figure 3. *Marsilea mutica* Mett. **A**. habit. **B**. sporocarp. Illustration by Wilawan Nuchthongmuang from *Petchsri et al. 2* (BCU).

M. crenata as a synonym of *M. minuta* based on our study (Table 1). Likewise, our work was also supported by the molecular phylogenetic analysis of the genus *Marsilea* by Nagalingum et al. (2007) and POWO (2019). However, Hassler (2019) still recognized *Marsilea minuta* L. and *M. crenata* C. Presl as separate species.

Based on critical investigation and field observations throughout Thailand, this present study revealed that the number of species in Thailand was two native and two introduced: *M. minuta*, *M. scalaripes*, *M. drummondii*, and *M. mutica*, respectively. *M. scalaripes* was named a new species by Johnson (1988) based on a fertile specimen: *Corner SFN 38109* from SING and a fragment of sporocarp from BM. So far, this species was known only from the type locality in Kedah, Malaysia (Parris and Latiff, 1997). Here, the full description of *M. scalaripes* based on fertile Thai specimens was prepared. In Thailand, this species was collected by O. Na-Thalang and kept at BCU since 1973 and was

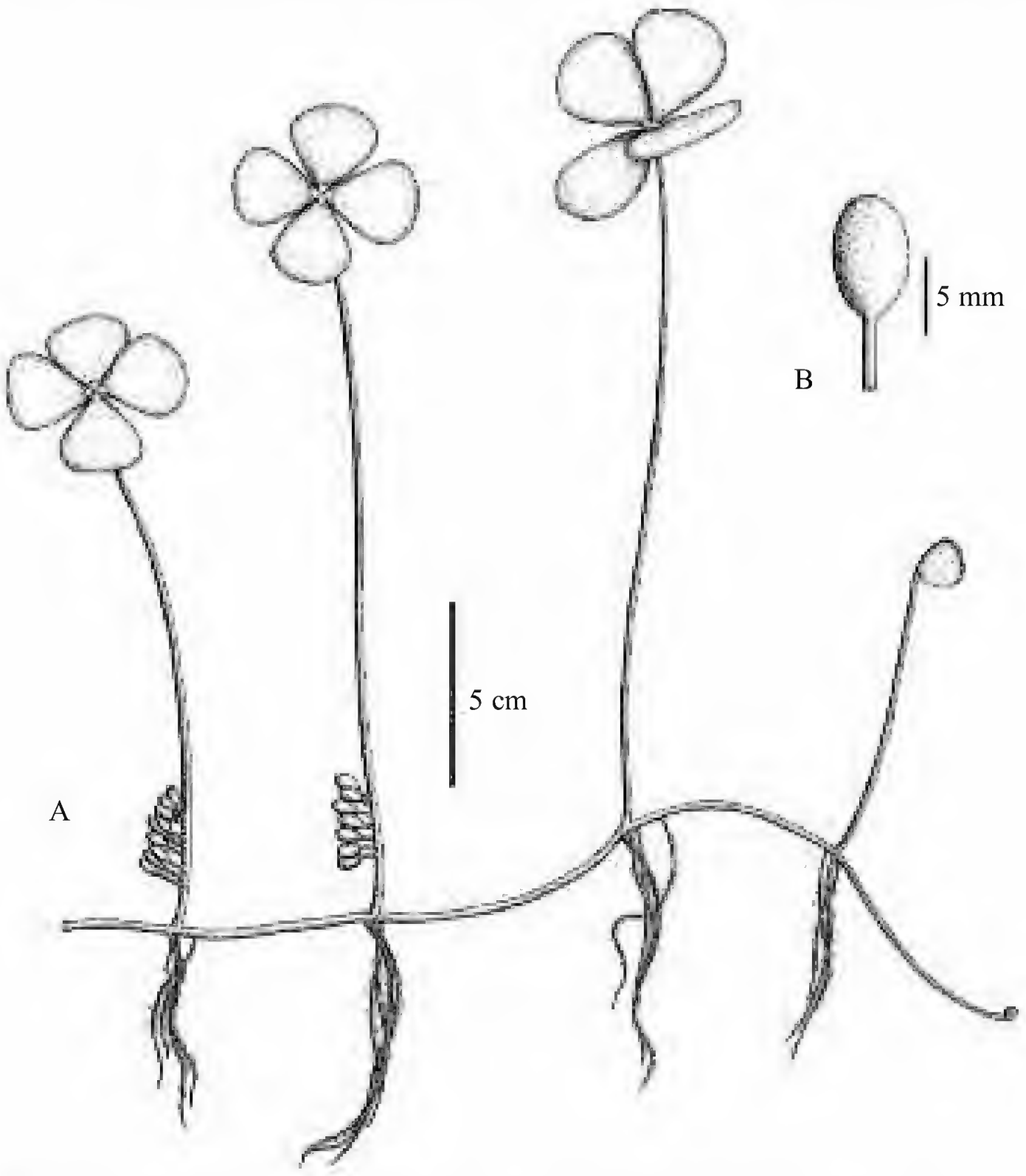

Figure 4. *Marsilea scalaripes* D.M. Johnson. **A**. habit. **B**. sporocarp. Illustration by Wilawan Nuchthongmuang from *T. Boonkerd 1870* (BCU).

determined as *M. polycarpa* Hook. & Grev. based on Holttum (1968). *M. scalaripes* tend to have a wider distribution since living specimens are found in the NE and SE regions of Thailand (Figure 5). However, we could not find any *M. scalaripes* from peninsular

Figure 5. Distribution of *Marsilea scalaripes* D.M. Johnson. **1** shows the type locality, Kedah Malaysia, from previous study. **2-6** show the present finding: 2. Chon Buri. 3. Nakhon Nayok. 4. Prachin Buri. 5. Nakhon Phanom. 6. Siemreap.

Thailand, although Johnson (1988) noted that *M. scalaripes* is a native Malay Peninsula species. Moreover, we found a herbarium specimen of this species in P (MNHN-P-P00106224) collected from Baray, Siemreap, Cambodia, but without a digitized specimen image. Morphologically, *M. minuta* shows some similarities with *M. scalaripes*, especially in their vegetative structure, but they differ in many aspects of the sporocarps (Fig. 2 & 4, Table 1). Both species are collected and sold as a vegetable in the market at Sisaket, NE Thailand (Poopath et al., 2018). Earlier *M. quadrifolia* was mentioned by Peudpaichit et al. (1987), Waterhouse (1993) and Holm et al. (1997) but is not recognized here. However, in Laos PDR, *M. minuta* and *M. quadrifolia* were recognized as native

TABLE 1. Comparison of *Marsilea minuta* with two native water clover species in Thailand.

Characters	***M.minuta****	***M.crenata****	***M.scalaripes****
Internode	Up to 10 cm long	Up to 5 cm long	Up to 10 cm long
Stipe	Up to 40 cm long, rather close	Up to 20 cm long, rather close	Up to 20 cm long, rather sparse
Leaflet shape and margin - size - indumentum	Obovate, entire to shallowly irregular Up to 18 × 16 mm Glabrous to sparsely hairy	Obovate, entire to shallowly irregular Up to 15 × 15 mm Glabrous to sparsely hairy	Obovate, entire Up to 16 × 14 mm Glabrous to sparsely hairy
Sporocarps - shape in lateral view - shape in vertical cross-section view - no. per frond - basal teeth - attaching - indumentum	Set at an angle of 90° to the pedicel, not ribbed Oblong-elliptic Elliptic 1–5 Present Clumped at stipe base Covered with caduceus hairs when young, later glabrate	Set at an angle of 90° to the pedicel, not ribbed Oblong Elliptic 3–5 Present Clumped at stipe base Covered with caduceus hairs when young, later glabrate	Set at an angle of almost 180° to the pedicel, ribbed Ovoid Terete 2–9(–12) Absent Lined upward on the lower half of stipe Thinly covered with matted hairs
Pedicels	Free or branching once	Free or branching once	Absolutely free

* from Johnson (1986) and Hyde *et al.* (2020), ** from this study, *M. crenata*: *T. Boonkerd 1871* [BCU]; *M. scalaripes*: *Zungsontiporn et al. 885* [BCU].

species (Kosaka et al., 2006; 2013; Newman et al., 2007; Gupta, 2011). We have seen a line drawing of *M. quadrifolia* from Vietnam, showing two sporocarps attached to the lower portion of the stipe (Pham, 1991). However, the sporocarp position did not match with the line drawing of *M. quadrifolia* in Johnson (1986) but tended to be like *M. scalaripes*. A study of a wide range of *M. quadrifolia* material in Cambodia, Laos PDR, and Vietnam would be required to confirm the present taxonomic status of this species.

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AN ANNOTATED CHECKLIST OF LYCOPHYTES AND FERNS OF THE SOLOMON ISLANDS

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Key Words: diversity, biogeography, flora, nomenclature, Pacific Islands, Papuasia, taxonomy, typification.

ABSTRACT

We provide an annotated checklist of all known lycophytes and ferns in the Solomon Islands following an updated classification. It comprises two classes, 12 orders, 34 families, 122 genera, 449 species, and six infraspecific taxa, including 10 new species described here and 18 species newly recorded for the country. In addition, we make six new nomenclatural combinations as well as 53 lectotypifications. We include a discussion of type status, taxonomic uncertainty, and recent molecular phylogenetic research when relevant. The life forms and phytogeographic affinities of all species are presented and briefly discussed.

INTRODUCTION

The Solomon archipelago is a double chain of islands that are oriented northwest–southeast in the western Pacific Ocean (Figure 1). This paper provides an updated checklist of the pteridophyte flora (lycophytes and ferns) of the Solomon Islands, in its political sense, including Santa Cruz Islands (Temotu Province), which are biogeographically part of Vanuatu. Bougainville, a province of Papua New Guinea, was excluded, although biogeographically it is the northernmost island of the Solomon Islands archipelago. Herbarium specimens and previous studies of pteridophytes were reviewed, followed by a critical re-examination of their systematics through the collaborative effort of 16 experts. Based on this checklist, the life forms and phytogeographic affinities of all recognised species are discussed briefly.

HISTORY OF PTERIDOPHYTE COLLECTION AND STUDY IN THE SOLOMON ISLANDS

Some of the earliest pteridophyte collections were made by William Brackenridge (1810–1893), who joined the United States Exploring Expedition from 1838 to 1842 as an assistant botanist, William John Macleay (1820–1891), who conducted a scientific expedition to New Guinea in 1875, and Charles Moore (1820–1905), who voyaged to New Caledonia, Vanuatu, and Vanikoro on the *H.M.S. Havannah*. Some of their collections from the Solomon Islands were described as new species by Mettenius (1863), Hooker (1861, 1864), Hooker & Baker (1874) and Baker (1891), including: *Acrostichum cultratum* Baker (≡ *Lomagramma cultrata* (Baker) Holttum), *Adiantum monosorum* Baker, *Cyathea brackenridgei* Mett. (≡ *Sphaeropteris brackenridgei* (Mett.) R.M.Tryon), *Davallia lapeyrousei* Hook. (≡ *Lindsaea lapeyrousei* (Hook.) Baker), *Gymnogramma quinata* Hook. (≡ *Syngramma quinata* (Hook.) Carruth.), *Nephrodium phanerophlebium* Baker (≡ *Plesioneuron phanerophlebium* (Baker) Holttum) and *Polypodium metcalfei* Baker (≡ *Sphaerostephanos metcalfei* (Baker) Holttum).

William Grant Milne (1829–1866) was a Scottish botanist at the Royal Botanic Garden Edinburgh. He joined the *Herald* expedition to the southwestern Pacific from 1852 to 1856, and the following four names were published using his collections from the Solomon Islands: *Asplenium persicifolium* var. *atrovirens* Hook. (≡ *Asplenium atrovirens* (Hook.) Baker), *Gymnogramma palmata* Baker (= *Tectaria christovalensis* (C.Chr.) Alston), *Lygodium trifurcatum* Baker, and *Stenochlaena milnei* Underw.

The English missionary Rev. R. B. Comins collected 60 species of pteridophytes mainly from Makira in 1882. His collection was sent to the British pteridologist John

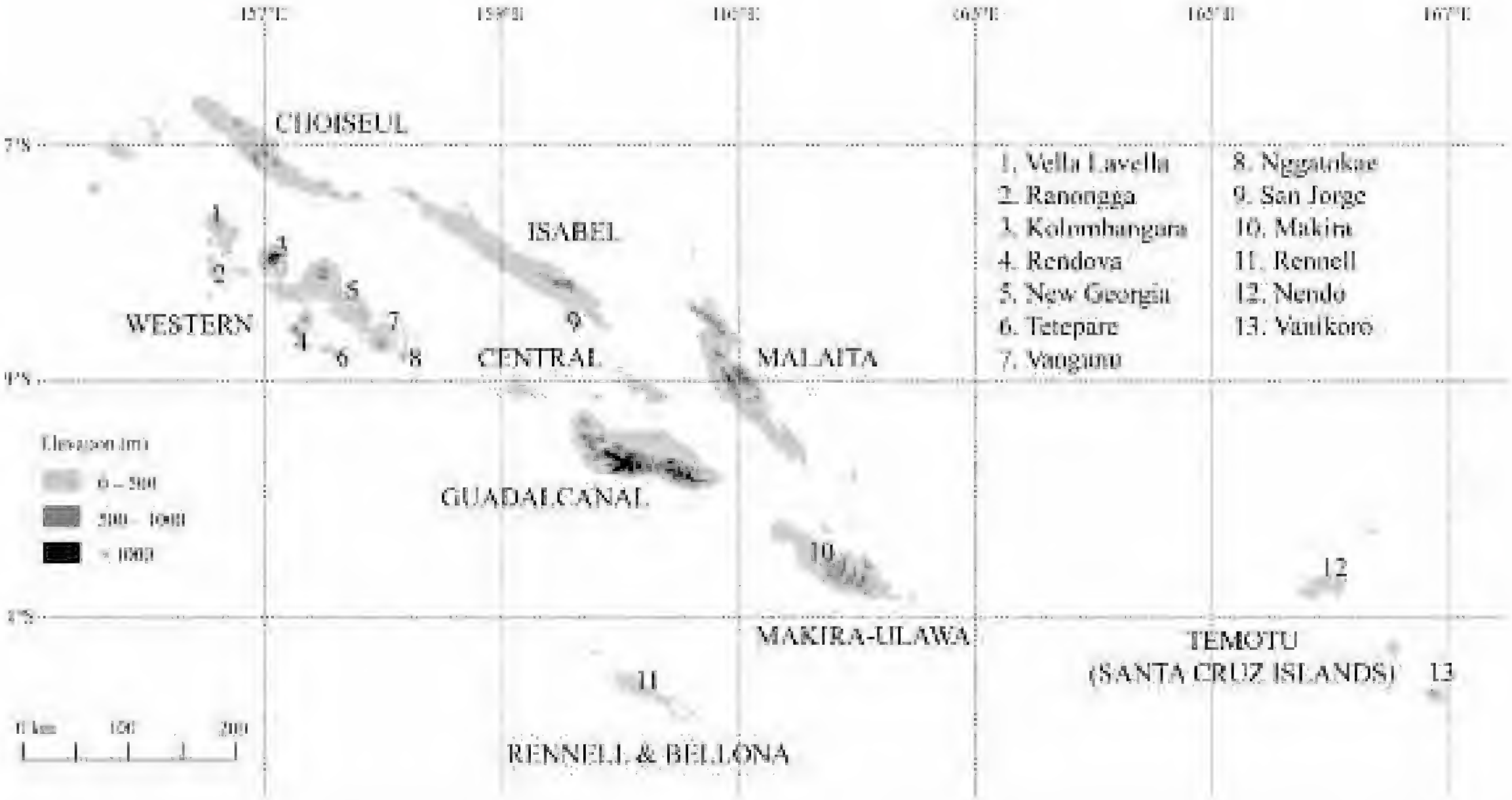


Figure 1. Map of the Solomon Islands. The names of the nine provinces are capitalised. In the geographical scheme of Brummitt (2001), most of the country belongs to Papuasia region, whereas Temotu Province belongs to Southwestern Pacific region. Smaller islands within the provinces from where voucher specimens were collected are also indicated.

Gilbert Baker, who published the earliest pteridophyte list of the Solomon Islands including the following new species (Baker, 1882): *Asplenium ludens* Baker (= *A. marattioides* (Brack.) C.Chr.), *Asplenium umbrosum* var. *cristovalense* Baker (≡ *Diplazium cristovalense* (Baker) C.W.Chen), *Aspidium semicordatum* var. *biauriculatum* Baker (= *Cyclopeltis novoguineensis* Rosenst.), *Nephrodium amboinense* var. *subglandulosum* Baker (= *Sphaerostephanos veitchii* Holttum), *Nephrodium hederifolium* Baker (≡ *Tectaria hederifolia* (Baker) C.Chr.), *Nephrodium macrosorum* Baker (= *Tectaria repanda* (Willd.) Holttum), and *Gymnogramma cominsii* Baker (≡ *Diplazium cominsii* (Baker) C.Chr).

Sethric Francis Kajewski (1904–1997?), an Australian, was hired by the Arnold Arboretum to collect plant specimens in the Pacific Islands from 1928 to 1932 (Kajewski, 1930, 1946). He collected 32 fern species (in a collection of 188 specimens) between October to December in 1928 on Vanikoro. At the end of 1930, Kajewski collected in the Langalanga lagoon area of Malaita, but with limited results owing to the non-cooperative authorities he met (Kajewski, 1946). He spent nearly all of the year 1931 on Guadalcanal, climbing via Gold Ridge to Mt. Tatuve, descending directly to the north coast (Kajewski, 1946). After five years Kajewski resigned as a collector for the Arnold Arboretum and was replaced by Leonard John Brass. New species later described by Copeland (1931, 1936) using Kajewski's collections from the Solomon Islands include: *Dennstaedtia tripinnatifida* Copel. (= *D. glabrata* (Ces.) C.Chr.), *Dryopteris odontophora* Copel. (= *D. hasseltii* (Blume) C.Chr.), *Gleichenia kajewskii* Copel. (= *Sticherus milnei* (Baker) Ching), *Lindsaea kajewskii* Copel. (= *L. lapeyrousei* (Hook.) Baker), *Lycopodium kajewskii* Copel. (≡ *Phlegmariurus kajewskii* (Copel.) A.R.Field & Testo), *Lycopodium vanikorense* Copel. (= *Phlegmariurus carinatus* (Desv. ex Poir.) Ching), *Oleandra angusta* Copel. (= *O. neriiformis* Cav.), *Sphaerostephanos unijuga* Copel. (= *S. polycarpos* (Blume) Copel.) and *Tmesipteris oblanceolata* Copel.

Leonard John Brass (1900–1971) was born in Queensland and trained at the Queensland herbarium (BRI). He collected 151 fern specimens (collecting numbers, including non-pteridophytes, 2548–3543) mainly on Makira and Santa Isabel between 22 July 1932 and 26 January 1933 for the Arnold Arboretum (A) and Queensland herbarium. Copeland (1936) described 14 new species using this material: *Angiopteris microura* Copel., *Antrophyum megistophyllum* Copel., *Cyathea alta* Copel. (≡ *Alsophila alta* (Copel.) R.M.Tryon), *Cyathea barotu* Copel. (= *Sphaeropteris vittata* (Copel.) R.M.Tryon), *Cyathea vittata* Copel. (≡ *Sphaeropteris vittata* (Copel.) R.M.Tryon), *Cyathea aciculosa* Copel. (≡ *Sphaeropteris aciculosa* (Copel.) R.M.Tryon), *Dryopteris doodioides* Copel. (≡ *Sphaerostephanos doodioides* (Copel.) Holttum), *Dryopteris malodora* Copel. (≡ *Chingia malodora* (Copel.) Holttum), *Dryopteris oxyoura* Copel. (≡ *Reholttumia oxyoura* (Copel.) S.E.Fawc. & A.R.Sm.), *Grammitis brassii* Copel. (≡ *Oreogrammitis brassii* (Copel.) Parris), *Histiopteris herbacea* Copel., *Oleandra dimorpha* Copel. (= *O. werneri* Rosenst.), *Scyphularia appressa* Copel. (= *Davallia pentaphylla* Blume), and *Tapeinidium tenuius* Copel. (= *T. denhamii* (Hook.) C.Chr.).
Chris John Hadley, a forestry officer who worked on the Santa Cruz Islands for three and a half years in the late 1950s (Hadley, 1991), collected about 50 fern species on Vanikoro and Nendo; these were sent to the Natural History Museum (BM). E. S. Brown worked for the Agriculture Department in Honiara and collected between 1954 and 1956 on Kolombangara, Guadalcanal, Rennell and Santa Isabel. He had two concurrent collecting series deposited in the herbarium of Ministry of Forestry and Research Department (BSIP): 1132 to 5379 and W2 to W352. Benjamin Clemens Stone (1933–

1994) visited the Solomon Islands in 1957 mainly to collect *Pandanus* but also collected 32 specimens of ferns on Guadalcanal (Tenaru), Malaita, Santa Isabel, Tulagi and Bougainville (Buka Island). *Humata pauxilla* B.C.Stone & Lane (= *Davallia pusilla* Mett.) was described from these collections.

During the Royal Society Expedition to the Solomon Islands in 1965, Anthony Forester Braithwaite (1936–2018) made a large collection of pteridophytes, now deposited mainly in K. His collection greatly improved our understanding of pteridophytes in the Solomon Islands, especially those from Mt. Popomanaseu which is the only known pteridophyte collection from the highest point in the country. His itinerary was: 2 to 13 Jul, Guadalcanal, RSS 4001–4134; 19 Jul to 11 Aug, Makira, RSS 4135–4331; 23 Aug to 8 Sep, Kolombangara, RSS 4336–4505; 20 Sep to 7 Oct, Santa Isabel, RSS 4510–4611; 19 Oct to 8 Nov, Guadalcanal, RSS 4613–4836; 19 to 28 Nov, Malaita, RSS 4841–4886. Many new species were published based on his collections by Holttum (1968a, 1975, 1976, 1977) and Braithwaite (1973), and now also this study.

The BSIP (British Solomon Islands Protectorate) series of the Forestry Department of the Solomon Islands constituted another major collection. These collections, housed in BSIP, were initiated by Geoffrey Dennis in 1962 on Guadalcanal. Timothy Charles Whitmore (1935–2002) began collecting in Oct 1962, and his itinerary was as follows: Oct 1962, Guadalcanal; Nov and Dec 1962, Kolombangara and Vangunu; May 1963, Santa Cruz; Sep 1963, New Georgia and Kolombangara; Oct 1963, Santa Isabel; Dec 1963, Malaita; Feb 1964, Choiseul and Baga islands; Apr 1964, Shortland Islands; May 1964, Makira. In 1966, he published the book "Guide to the Forests of the British Solomon Islands" (Whitmore, 1966); there he included a checklist of the vascular plants by integrating the earliest BSIP collections (by H. B. S. Womersley, P. J. Grubb and himself), the Brown collections, the Brass collections, and the Hadley collections. Whitmore also included names based on specimens at Kew and publications such as Copeland (1936).

Following 1965, some ferns were collected by Forestry Department workers and Land Inventory staff at a time when the main emphasis was on collection of tree specimens. The collectors of ferns included R. Teona, on Ulawa in Feb 1965; A. Nakisi, on Guadalcanal in 1967; J. R. F. Hansell, on Malaita and Ulawa in Mar to May 1969; J. M. Powell, on Santa Cruz in Apr to May 1972. Margaret Tedder, wife of James Tedder who was the governor of the British colony, lived in the Solomon Islands from 1952–1974. She collected 21 specimens of ferns between 1972 to 1974, mainly on Guadalcanal, and included vernacular names and abundant information on traditional uses. Francis John Newhook (1918–1999) from Auckland University collected 54 specimens of ferns between 1972 and 1978 from Malaita, while working for the Department of Agriculture. Duplicates of the above specimens were deposited in several herbaria including BISH, BSIP, CANB, L, and US.

Between Mar and Apr 1988, Christopher Henderson collected 28 fern specimens, of which the first set is held at Dodo Creek Research Station, Guadalcanal, with duplicates at BSIP. While compiling information for his book (Henderson & Hancock, 1988), Henderson collected on Guadalcanal, Malaita, Santa Isabel, New Georgia, and Rennell. Henderson & Hancock (1988) and Hancock & Henderson (1988) both contain the same checklist, based on Whitmore's 1966 checklist but adding names from specimens in BSIP, i.e., collections of the Royal Society expedition, Forestry Department collectors and Henderson's own collections. In total, 466 pteridophyte taxa, some unidentified, were included in their checklist.

From 1990 to 1992, as a volunteer, David Glenny collected 744 pteridophyte specimens (Glenny 1633–3557) on the following itinerary: 8–22 Mar 1990, Choiseul, Moli; Mar to Apr 1990, near Honiara; 12–19 May 1990, Guadalcanal, Mt. Makarakomburu; 17–26 Jul 1990, Kolombangara, Poitete and Iriri; 29–30 Jul and 7–12 Nov 1990, Gizo; 14–27 Aug 1990, Malaita, South East; 5 Sep 1990, Rennell; 15–20 Nov 1990; Mono; 14–19 Apr 1991, Pavuvu; 4–8 Apr 1991, Tulagi and Nggela Sule; 20–24 Jun 1991, Guadalcanal; 30 Jul to 2 Aug 1991, Santa Isabel; 8–13 Aug and 15–17 Sep 1991, Kolombangara; 9–12 Sep 1991, Rendova; 21–23 Sep 1991, Guadalcanal; 14–23 Jan 1992, Guadalcanal; and 13 Feb 1992, Guadalcanal, Mt. Chonapau. The first set of his collections was deposited in BSIP with duplicates in WELT. In 2015, as part of an expedition involving the University of the South Pacific and the Solomon Islands Community Conservation Partnership, Leon Perrie made 163 pteridophyte collections of 140 species from the northern mid-slopes of Mt. Popomanaseu, with specimens in BSIP, SUVA, and WELT.

The latest and largest pteridophyte collection was made by Cheng-Wei Chen under the project "Census and Classification of Plant Resources in the Solomon Islands", which ran from 2012 to 2016. The other collectors who also made numerous pteridophyte collections under the project were Tian-Chuan Hsu, Hsin-Chieh Hung, and Moffat Fanerii. Altogether, more than 10,000 pteridophyte specimens were collected throughout the country, and these represent over 400 species. Their itinerary was as follows: Aug to Oct 2012, Guadalcanal, Kolombangara, and New Georgia; Jul to Nov 2013, Kolombangara, Nggatokae, Ranongga, Rendova, Tetepare, Vangunu, and Vella Lavella; Jun to Jul 2014, Guadalcanal, Kolombangara, Rennell, and Santa Isabel; Jun to Sep 2015, Guadalcanal, Kolombangara, Makira, and Malaita; Jun to Jul 2016, Guadalcanal, San Jorge, and Santa Cruz Islands. Unfortunately, no collections were made from the high mountains of Guadalcanal. As a result, those species known only from Mt. Popomanaseu are missing from this collection. A result of this project was the book "*Sol Amazing: lycophytes and ferns of the Solomon Islands*" (Chen et al., 2017a), in which 370 species were illustrated.

MATERIALS AND METHODS

Over 3600 specimens collected from the Solomon Islands and deposited in the herbaria AK, BAS, BM, BSIP, CHR, CNS, K, L, MICH, TAIF, TNM, UC, US, VT and WELT have been examined and verified. Herbarium abbreviations follow Index Herbariorum (http://sweetgum.nybg.org/science/ih/). The updated checklist of ferns and lycophytes was constructed based mainly on 1) an unpublished fern flora from the third author (Glenny, unpubl.) that incorporated the results from his own and previous studies; and 2) the more recent collections from the "Census and Classification of Plant Resources in the Solomon Islands" project conducted from 2012 to 2016. The circumscription for families and genera of PPG I (2016) was followed, but with some exceptions described herein. A different classification was used only if there was convincing alternative evidence, and the references were provided accordingly.

Field observation or the information on specimen labels was used to record the life form of each species. Species were recorded as belonging to one of the following six life forms: aquatic, terrestrial, epiphytic, rupestral, climbing, and tree ferns. When more than one life form was observed, the more common one was recorded. Some species with a juvenile stage growing on the ground but with mature stages on trees, sometimes called "hemiepiphytic" (Zotz, 2013; Testo & Sundue, 2014), were recorded as epiphytes.

The geographical scheme of Brummitt (2001) was used to record the distribution of species. For each species, its presence/absence was recorded in the following 11 regions, with the codes used in Brummitt (2001) indicated in parentheses: China (36), Eastern Asia (38), India Subcontinent (40), Indo-China (41), Malesia (42), Papuasia (43), Australia (50), Southwestern Pacific (60), South-Central Pacific (61), Northwestern Pacific (62), and North-Central Pacific (63) [refer to maps 6 and 10 in Brummitt (2001) for delimitation of the above 11 geographical elements]. In Brummitt (2001), the Solomon Islands were divided into two regions: most of the country belongs to Papuasia (43), whereas Santa Cruz Islands belongs to Southwestern Pacific (60). When species occurred beyond these regions, they were recorded either as paleotropical, pantropical, or cosmopolitan, according to their distribution. The distribution of each species mainly follows Brownsey & Perrie (2011, Fiji), Hassler (2021, global), Field (2020, Australia), Fraser-Jenkins et al. (2017, 2018a, 2021, India), Lindsay & Middleton (2012 onwards, Cambodia, Laos and Thailand), Cámara-Leret et al. (2020, New Guinea), TPG (2019, Taiwan), Wu et al. (2013, China), and the Flora Malesiana series (https://floramalesiana.org/).

PTERIDOFLORA OF THE SOLOMON ISLANDS AND ITS AFFINITIES

Floristic patterns

In total, 34 families, 122 genera, 449 species, and six infraspecific taxa of pteridophytes were recorded. This is about 10% of the vascular plant flora of the Solomon Islands, estimated at 4,500 species (Watanabe et al., 2010). The top five species-rich families made up over half (225 taxa) of the pteridoflora of the Solomon Islands: Polypodiaceae (74 taxa), Thelypteridaceae (47 taxa), Pteridaceae (41 taxa), Hymenophyllaceae (34 taxa), and Lindsaeaceae (29 taxa). The five genera with the greatest number of taxa in the Solomon Islands were *Asplenium* (25 taxa, Aspleniaceae), *Lindsaea* (22 taxa, Lindsaeaceae), *Oreogrammitis* (21 taxa, Polypodiaceae), *Tectaria* (20 taxa, Tectariaceae), and *Diplazium* (18 taxa, Athyriaceae).

Life forms

Not surprisingly, the two most common life forms were terrestrials and epiphytes, and together they accounted for 87% of the pteridophyte diversity of the Solomon Islands

Table 1. Categorisation of the Solomon Islands pteridoflora by life form.

Life form	No. of taxa
Terrestrial	218 (47.9%)
Epiphytic	179 (39.3%)
Climbing	21 (4.6%)
Rupestral	17 (3.7%)
Tree ferns	18 (3.9%)
Aquatic	2 (0.4%)

(Table 1). There were 218 terrestrial taxa in the Solomon Islands, and these account for nearly half of the pteridoflora. Among them, Thelypteridaceae (45 taxa), Pteridaceae (24 taxa), and Tectariaceae (20 taxa) are the three most species-rich families. Among the 179 epiphytic taxa that account for 39.3% of total diversity, Polypodiaceae (69 taxa), Hymenophyllaceae (23 taxa), and Aspleniaceae (20 taxa) are the three most diverse families.

Affinities of ferns and lycophytes of the Solomon Islands

The distribution of 438 taxa in the 11 geographic regions is shown in Table 2, which excluded the 17 unidentified taxa. As expected, the Solomon Islands shared most taxa with neighbouring regions, including Papuasia, Malesia and Southwestern Pacific. Twenty biogeographic elements (Table 3, A to T) were recognised, based on the distribution of taxa. The three largest biogeographic elements of the pteridoflora were B. Papuasia (56 taxa), E. Papuasia + Malesia (56 taxa), and D. Papuasia + Southwestern Pacific (46 taxa). The pteridoflora of the Solomon Islands has a strong affinity with that of New Guinea. This is probably the result of the geographic proximity of the Solomon Islands to New Guinea, the largest island flora in the world (Cámara-Leret et al., 2020). The Southwestern Pacific Island taxa are also well represented in the Solomon Islands. Among the 46 taxa (element D) shared with Southwestern Pacific, the Solomon Islands

Table 2. Shared pteridophyte species between the Solomon Islands and 11 geographic regions of Brummitt (2001).

Geographic reigion	No. of shared species
Papuasia (43)*	433
Malesia (42)	285
Southwestern Pacific (60)*	247
Indo-China (41)	137
Australia (50)	132
India Subcontinent (40)	101
Eastern Asia (38)	98
South-Central Pacific (61)	91
Northwestern Pacific (62)	89
China (36)	86
North-Central Pacific (63)	34

* In Brummitt (2001), most of the Solomon Islands belongs to the Papuasia region (43), whereas Temotu Province belongs to the Southwestern Pacific region (60)

Table 3. Breakdown of the Solomon Islands pteridoflora by biogeographic element.

Biogeographic element	No. of taxa
A. Endemic (43) + (60)	2
A. Endemic (43)	21
A. Endemic (60)	4
B. Papuasia (43)	56
C. Southwestern Pacific (60)	9
D. Papuasia (43) + Southwestern Pacific (60)	46
E. Papuasia (43) + Malesia (42)	56
F. Papuasia (43) + Pacific (60–63)	6
G. Australia (50) + Pacific (60–63)	2
H. Papuasia (43) + Malesia (42) + Australia (50)	9
I. Papuasia (43) + Malesia (42) + Pacific (60–63)	21
J. Papuasia (43) + Australia (50) + Pacific (60–63)	8
K. Papuasia (43) + Malesia (42) + Australia (50) + Pacific (60–63)	12
L. Asia-Tropical (40–43)	12
M. Asia-Tropical (40–43) + Australia (50)	3
N. Asia-Tropical (40–43) + Pacific (60–63)	46
O. Asia-Tropical (40–43) + Australia (50) + Pacific (60–63)	9
P. Asia-Temperate (30–38) + Asia-Tropical (40–43)	11
Q. Asia-Temperate (30–38) + Asia-Tropical (40–43) + Australia (50)	3
R. Asia-Temperate (30–38) + Asia-Tropical (40–43) + Pacific (60–63)	15
S. Asia-Temperate (30–38) + Asia-Tropical (40–43) + Australia (50) + Pacific (60–63)	44
T. Paleotropical, Pantropical, or Cosmopolitan	43

are the westernmost distribution of 17 taxa and they are not recorded in New Guinea and its surrounding islands. Another nine southwestern Pacific endemics are recorded in the Santa Cruz Islands (element C, *Austrogramme decipiens* (Mett.) Hennipman, *Blechnum phanerophlebium* C.Chr., *Davallia graeffei* Luerss., *Davallia leptocarpa* Mett. ex Kuhn, *Dennstaedtia flaccida* (G.Forst.) Bernh., *Lomagramma polyphylla* Brack., *Ptisana smithii* (Mett. ex Kuhn) Murdock, *Reholttumia magnifica* (Copel.) S.E.Fawc. & A.R.Sm., and *Sphaerostephanos metcalfei* (Baker) Holttum).

The second largest component of the pteridoflora were widely distributed taxa, including those across Asia, Australia, Pacific Islands, or beyond (elements N with 46 taxa, S with 44 taxa, and T with 43 taxa). The remaining elements were all minor, and collectively they account for only 31.2% (137 taxa) of the total diversity, with each contributing less than 5%.

Endemism

Among the 455 accepted taxa, only 27 (5.6%) are recognised as endemic (Table 4). In comparison with other Pacific Islands, the percentage of endemics in the Solomon Islands is only slightly higher than that of Vanuatu (4.4%), and lower than Fiji, with 48 endemics among 331 taxa (15%) (Brownsey & Perrie, 2011). The primary reason for the low rate of endemism is probably the short distances between the Solomon Islands and other nearby islands. For example, the distances between Guadalcanal and New Guinea or the Bismarck Archipelago is only about 1,000 km, which is not a major barrier to fern spore dispersal (Shepherd et al., 2009). This is supported by the 369 taxa shared by the Solomon Islands and New Guinea (including its surrounding islands). Presumably all available habitats in the Solomon Islands were occupied quickly as they came into existence, leaving almost no room for the in-situ evolution of new species from those that had arrived, a concept that has been termed niche pre-emption (Fukami, 2015). With no major geographic barriers, the continued genetic exchange between the Solomon Islands and New Guinea has likely impeded speciation. It is worth mentioning that if the Solomon Islands are viewed from a biogeographic perspective, i.e., including Bougainville but excluding the Santa Cruz Islands, seven additional species (*Alsophila solomonensis* (Holttum) R.M.Tryon, *Amauropelta rechingeri* (Holttum) S.E.Fawc. & A.R.Sm., *Cystodium sorbifolium* (Sm.) J.Sm. subsp. *solomonense* J.R.Croft, *Sphaeropteris brackenridgei* (Mett.) R.M.Tryon, *Selaginella poperangensis* Hieron., *Plesioneuron myriosorum* (Copel.) Holttum and *Sphaerostephanos braithwaitei* Holttum) would be recognised as endemic, but the nine species found only in the Santa Cruz Islands would be removed from the list.

Endemism within families is highly uneven, with just two families (i.e., nine taxa each in Polypodiaceae and Thelypteridaceae) comprising almost 70% (18 species) of all endemics. Among the 27 endemic species, eight are newly described in this study. Further studies in neighbouring countries, especially Papua New Guinea, might expand the distribution of these new species and thus decrease the endemism of the Solomon Islands. On the other hand, this may be balanced by new endemics being recognised through ongoing studies.

AN UPDATED CHECKLIST OF FERNS AND LYCOPHYTES OF THE SOLOMON ISLANDS

Abbreviations for the author's names and publications follow the International Plant Names Index (https://www.ipni.org/), Taxonomic Literature II

Table 4. List of 27 species endemic to the Solomon Islands and their distribution within the country.

Taxa	Distribution
Archigrammitis solomonensis Parris	Kolombangara
Calymmodon furcatus Parris	Guadalcanal
Calymmodon solomonensis Parris	Guadalcanal
Calymmodon subgracilis Parris	Guadalcanal and Kolombangara
Chingia malodora (Copel.) Holttum	Widely distributed except Santa Cruz Islands
Chingia tortuosa S.E.Fawc., C.W.Chen & A.R.Sm.	Santa Cruz Islands
Christella harveyi (Mett. ex Kuhn) Holttum var. *connivens* Holttum	Guadalcanal
Coryphopteris kolombangarae Holttum	Western Province
Coryphopteris subbipinnata Holttum	Guadalcanal and Kolombangara
Diplazium cominsii (Baker) C.Chr.	Widely distributed throughout the country
Diplazium cristovalense (Baker) C.W.Chen	Makira
Histiopteris herbacea Copel.	Widely distributed throughout the country
Lindsaea jarrettiana K.U.Kramer	Guadalcanal and Kolombangara
Lindsaea salomonis K.U.Kramer	Guadalcanal and Kolombangara
Lomagramma cultrata (Baker) Holttum	Makira
Oreogrammitis brassii (Copel.) Parris	Makira
Oreogrammitis dissimulans Parris	Santa Cruz Islands
Oreogrammitis peregrina Parris	Guadalcanal
Oreogrammitis rupicola Parris	Santa Cruz Islands
Plesioneuron phanerophlebium (Baker) Holttum	Santa Cruz Islands
Plesioneuron subglabrum Holttum	San Jorge
Ptisana ambulans Murdock & C.W.Chen	New Georgia
Reholttumia oxyoura (Copel.) S.E.Fawc. & A.R.Sm.	Widely distributed except Santa Cruz Islands
Sphaerostephanos scandens Holttum	Widely distributed except Santa Cruz Islands
Tectaria hederifolia (Baker) C.Chr.	Makira
Tmesipteris solomonensis Braithwaite	Guadalcanal and Kolombangara
Tomophyllum pulchrum Parris	Guadalcanal

(https://www.sil.si.edu/DigitalCollections/tl-2/) and Botanico-Periodicum-Huntianum Online (http://fmhibd.library.cmu.edu/HIBD-DB/bpho/home.php), but with capital initial letters. For each accepted taxon, basionym, homotypic synonyms and replaced synonyms are cited. Heterotypic synonyms are cited only if they were typified by specimens from the Solomon Islands. The life form (see Table 1, A: aquatic. C: climbing, E: epiphytic, R: rupestral, T: terrestrial, TF: tree ferns) and biogeographic element (see Table 3, A to T) are indicated after each accepted name. Type information is as comprehensive as possible, mainly through JSTOR Global Plants (https://plants.jstor.org/) or with the assistance of herbarium staff (see Acknowledgments). Whenever possible, required lectotypifications were conducted in accordance with articles in the International Code of Nomenclature for algae, fungi, and plants (ICN; Turland et al., 2018), but only after reviewing the relevant protologues, references and original materials. A voucher from the Solomon Islands is also cited. With the intention to make this study compatible with Chen et al. (2017a), the voucher illustrated there was selected whenever possible. Lastly, in a Note, taxonomic issues or name changes from Chen et al. (2017a) are addressed for those species where this is relevant or helpful. Specimens collected by unknown collectors or lacking a collection number are indicated by *s.c.* (*sine collector*) and *s.n.* (*sine numero*), respectively. Specimens cited with the annotation '!' have been physically examined, specimens with the annotation '*' have been seen as high-resolution images, and specimens without any annotation have not been seen by the authors. The descriptions of the new species are provided after the checklist.

LYCOPODIACEAE P.Beauv. ex Mirb., *Hist. nat. vég.* 4: 293 (1802)

DIPHASIASTRUM Holub, *Preslia* 47: 104 (1975)

Diphasiastrum angustiramosum (Alderw.) Holub, *Preslia* 47: 107 (1975). T, B

Lycopodium complanatum L. var. *angustiramosum* Alderw., *Bull. Jard. Bot. Buitenzorg*, ser. 2, 24: 6 (1917)

Type: INDONESIA (Indonesian New Guinea), *Pulle 1032*, lectotype: BO, designated here by Field; isolectotypes: BONN-Nessel, G, L [3478646*], SING, UC [265362*], U [0007458*].

Voucher: Guadalcanal, 2347 m [7700 ft], 17 Jan 1967, *Dennis BSIP 7863*, BSIP!

HUPERZIA Bernh., *J. Bot. (Schrader)* 1800(2): 126 (1801)

Huperzia javanica (Sw.) Chun-Yu Yang, *Bull. Acad. of Military Med. Sci.* 13(5): 368 (1989). T, S

Lycopodium javanicum Sw., *Syn. Fil.* 175, 399 (1806)

Type: INDONESIA (Java), *Thunberg s.n.*, holotype: UPS-THUNB [25320B*].

Voucher: Guadalcanal, 2133 m [7000 ft], 29 Oct 1965, *Braithwaite RSS 4682*, BSIP!

Note: This species has usually been identified as *H. serrata* (Thunb.) Trevis., described from Japan. However, plants from the Solomon Islands differ by having leaves that are only slightly serrate near their apices (rather than strongly toothed as in the type of *H. serrata*). The name *H. javanica* is provisionally applied here due to the unresolved taxonomy of the *H. serrata* complex; the Solomon Island plants appear morphologically closer to Indonesian plants.

LYCOPODIUM L., *Sp. Pl.* 2: 1100 (1753)

Lycopodium japonicum Thunb., *Syst. Veg.*, ed. 14, 944 (1784). T, R

Stachygynandrum japonicum (Thunb.) P.Beauv., *Prodr. Aethéogam.* 113 (1905)

Type: JAPAN. *Thunberg s.n.*, lectotype: UPS-THUNB [25320*], designated by Zhang & Kung (2000); isolectotypes: LD [1744833*], S-P [12435*].
Voucher: Guadalcanal, 1981 m [6500 ft], 9 Nov 1962, *Dennis BSIP 524*, BSIP!
Note: The species diversity and taxonomy of the *L. clavatum* group is complex, and the specific identity of the Solomon Islands population is unresolved. The name *L. japonicum* is provisionally applied here pending further research.

PALHINHAEA Franco & Vasc., *Bol. Soc. Brot.*, sér. 2, 41: 24 (1967), *nom. cons.*
Palhinhaea cernua (L.) Franco & Vasc., *Bol. Soc. Brot.*, sér. 2, 41: 25 (1967). T, T
Lycopodium cernuum L., *Sp. Pl.* 2: 1103 (1753); *Lycopodiella cernua* (L.) Pic.Serm., *Webbia* 23: 166 (1968)
Type: UNKNOWN, *s.c., s.n.*, lectotype: LINN [1257.13*], designated by Proctor (1977).
Voucher: Vanikoro, 20–250 m, 20 Jun 2016, *Chen et al. SITW11025*, BSIP!, TNM! (lowland form); Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10578*, BSIP!, TAIF [520570!] [520571!], TNM! (montane form).
Note: *Palhinhaea cernua* is morphologically diverse globally and is probably best regarded as a species complex. Two morphological forms (lowland and montane) are present in the Solomon Islands (Chen et al., 2017a).

PHLEGMARIURUS Holub, *Preslia* 36(1): 17, 21 (1964)
Phlegmariurus carinatus (Desv. ex Poir.) Ching, *Acta Bot. Yunnan*. 4(2): 120 (1982). E, S
Lycopodium carinatum Desv. ex Poir., *Encycl. Suppl.* 3: 555 (1814) ['1813']; *Huperzia carinata* (Desv. ex Poir.) Trevis., *Atti Soc. Ital. Sci. Nat.* 17(2): 247 (1874)
Type: PAPUA NEW GUINEA (New Ireland, Praslin), *Commerson s.n.*, lectotype: P [00677324*], designated by Øllgaard (1989); isolectotype: P [00523011*].
Voucher: Kolombangara, 30–60 m, 11 Nov 2013, *Chen et al. SITW04657*, BSIP!, TAIF [464570!] [464571], TNM!
Note: The type gathering is consistent with material from Port Praslin, New Ireland, rather than Praslin Island, Seychelles, where it has never been collected again (Field 2020). *Lycopodium vanikorense* Copel., described from Vanikoro, is a synonym of this species.

Phlegmariurus dalhousieanus (Spring) A.R.Field & Bostock, *PhytoKeys* 20: 38 (2013). E, K
Lycopodium dalhousieanum Spring, *Mém. Acad. Roy. Sci. Belgique* 24: 25 (1849); *Huperzia dalhousieana* (Spring) Trevis., *Atti Soc. Ital. Sci. Nat.* 17(2): 247 (1874)
Type: MALAYSIA (Peninsular Malaysia, Penang), *Lady Dalhousie 36*, holotype: K [000672189*].
Voucher: Kolombangara, 450 m, 5 Apr 2017, *Hung et al. SITW13013*, BSIP!, TAIF [523879!], TNM!

Phlegmariurus filicaulon (Copel.) A.R.Field & Testo, *Molec. Phylogen. Evol.* 94(B): 645 (2015). E, B
Lycopodium filicaulon Copel., *Philipp. J. Sci.* 60: 100 (1936); *Urostachys copelandii* Herter, *Estud. Bot. Reg. Uruguay* 20: 57 (1949), *nom. superfl.*
Type: PAPUA NEW GUINEA (Bougainville), *Kajewski 2069*, holotype: PNH, destroyed; lectotype: MICH [1287174*], designated here by Field; isolectotypes: BISH [1000365*],

BM [0016727*], BRI-AQ [0149708*], NY [00127350*], P [01219325*] [00523012*], UC [574158*].
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04926*, BSIP!, TAIF [463832!], TNM!
Note: *Lycopodium filicaulon* Copel. is not a homonym of *L. filicaule* Hook.f. according to Article 53.1: "spelled exactly like a name based on a different type" (John McNeill pers. comm. May 2021, Kanchi Gandi pers. comm. May 2021). *Lycopodium filicaulon* is derived from Greek whereas *L. filicaule* is derived from a Latin adjective. The holotype in PNH (Copeland 1936) was destroyed; we selected the sheet from Copeland's private herbarium (now at MICH) as lectotype.

Phlegmariurus harmsii (Nessel ex Herter) A.R.Field & Bostock, *PhytoKeys* 20:41 (2013). E, K
Urostachys harmsii Nessel ex Herter, *Revista Sudamer. Bot.* 6: 166 (1940)
Type: MICRONESIA (Kosrae), *Kanehira 1316*, holotype: A; isotypes: NY [127353*], US [1917849*].
Voucher: Kolombangara, 300–600 m, 17 Oct 2013, *Chen et al. SITW04961*, BSIP!, TAIF [463866!], TNM!
Note: The holotype is stated to be in A (now in GH), but no material has been located there. This widespread Oceanian species may be conspecific with *P. mirabilis* (Willd.) A.R.Field & Testo from India and Sri Lanka, but further comparisons are needed. Material from India and Sri Lanka can have thicker and sometimes quadrangular fertile spikes, whereas the Solomon Island and Oceanian material has slender and strictly terete, multibranched fertile spikes.

Phlegmariurus kajewskii (Copel.) A.R.Field & Testo, *Molec. Phylogen. Evol.* 94(B): 645 (2015). E, J
Lycopodium kajewskii Copel., *J. Arnold Arbor.* 12: 48 (1931)
Type: SOLOMON ISLANDS (Vanikoro), *Kajewski 573*, holotype: UC [422659*]; isotypes: BRI-AQ [326730*], GH [021588], MICH [1287172*], MO [022131], US [00134331*].
Voucher: Vanikoro, 420–780 m, 18 Jun 2016, *Chen et al. SITW11012*, BSIP!, TAIF [498882!] TNM!

Phlegmariurus ledermannii (Herter) A.R.Field & Bostock, *PhytoKeys* 20: 42 (2013). E,T
Lycopodium ledermannii Herter, *Bot. Jahrb. Syst.* 54(3): 232 (1916); *Urostachys ledermannii* (Herter) Herter ex Nessel, *Bärlappgewächse* 236 (1939); *Huperzia ledermannii* (Herter) Holub, *Folia Geobot. Phytotax.* 20(1): 74. 198 (1985)
Type: PAPUA NEW GUINEA, *Keysser 199*, lectotype: S-P [13885*], designated by Field (2020); isolectotypes: S-P [25*], B [20 0113030!], UC [391743!].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10438*, BSIP!, TAIF [519454!], TNM!
Note: This species belongs to the *P. phlegmaria* complex and was identified as *P. phlegmaria* (L.) T.Sen & U.Sen in Chen et al. (2017a). However, our unpublished phylogenetic analysis shows that the Solomon Islands plants are only distantly related to *P. phlegmaria* from Asia and are instead closer to *P. australis* (G.Forst.) A.R.Field.

Phlegmariurus longus (Copel.) A.R.Field & Bostock, *PhytoKeys* 20: 42 (2013). E, B
Lycopodium longum Copel., *Philipp. J. Sci.* 60: 100, t.3 (1936)
Type: PAPUA NEW GUINEA (Bougainville), *Kajewski 1953*, holotype: PNH, destroyed; lectotype: MICH [1287171*], designated here by Field; isolectotypes: BM [000016725*], BRI-AQ [0149737], GH [00135530*].
Voucher: Malaita, 150–350 m, 22 Jul 2015, *Chen et al. SITW07700*, BSIP!, TNM!
Note: Close to *P. lauterbachii* (E.Pritz. ex Schumann & Lauterb.) A.R.Field & Bostock from New Guinea and possibly conspecific. *Phlegmariurus longus* has a laxer habit, with extremely long stems, compared to *P. lauterbachii*, which is robust, stiff, and shorter-stemmed. We selected the sheet from Copeland's private herbarium (now at MICH) as lectotype.

Phlegmariurus nummulariifolius (Blume) Ching, *Acta Bot. Yunnan.* 3(3): 298 (1981). E, N
Lycopodium nummulariifolium Blume, *Enum. Pl. Javae* 2: 263 (1828)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L [0057363*], designated by Field (2018); possible isolectotype: NY [00127360*].
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10583*, BSIP!, TAIF [520053!], TNM!

Phlegmariurus patentissimus (Alderw.) A.R.Field & Bostock, *PhytoKeys* 20: 45 (2013). E, E
Lycopodium patentissimum Alderw., *Bull. Jard. Bot. Buitenzorg*, ser. 2, 24: 4 (1917); *Huperzia patentissima* (Alderw.) Holub, *Folia Geobot. Phytotax.* 20(1): 75 (1985); *Urostachys patentissimus* (Alderw.) Herter ex Nessel, *Bärlappgewächse* 226 (1939)
Type: INDONESIA (Indonesian New Guinea), *Pulle 462*, lectotype: BO, designated by Øllgaard (1989); isolectotypes: BONN-Nessel [574!], L [0057365*], U [0007445!].
Voucher: Makira, 910 m, 1 Jul 2015, *Chen et al. SITW06869*, BSIP!, CNS!, TAIF [482819!], TNM!, VT [285130!].
Note: This species was misidentified as *P. oceanianus* (Herter) A.R.Field & Bostock in Chen et al. (2017a) but differs in its shorter and more densely arranged leaves. Subsequent molecular evidence places it closer to *P. patentissimus* from New Guinea (Field et al., unpublished data). It is more robust with denser leaves than the type of *P. patentissimus* from Indonesian New Guinea but closely resembles material identified as that species from eastern Papua New Guinea.

Phlegmariurus phlegmarioides (Gaudich.) A.R.Field & Bostock, *PhytoKeys* 20: 45 (2013). E, K
Lycopodium phlegmarioides Gaudich., *Voy. Uranie* 281 (1828); *Urostachys phlegmarioides* (Gaudich.) Herter ex Nessel, *Bärlappgewächse* 247 (1939); *Huperzia phlegmarioides* (Gaudich.) Rothm., *Feddes Repert. Spec. Nov. Regni Veg.* 54: 62 (1944)
Type: INDONESIA (Maluku), *Gaudichaud s.n.*, lectotype: P [02141894*], designated by Field (2020); isolectotypes: B [20113689*], K [001094157*], FI [004229*].
Voucher: Vanikoro, 420–780 m, 18 Jun 2016, *Chen et al. SITW11015*, BSIP!, TNM!

Phlegmariurus proliferus (Blume) A.R.Field & Bostock, *PhytoKeys* 20: 46 (2013). E, E
Lycopodium proliferum Blume, *Enum. Pl. Javae* 2: 265. (1828); *Urostachys prolifer*

(Blume) Herter, *Index Lyc.* 77 (1949); *Huperzia prolifera* (Blume) Trevis., *Atti Soc. Ital. Sci. Nat.* 17(2) (1874)
Type: INDONESIA (Java, Gede), *Blume s.n.*, lectotype: L [0057380!*], designated here by Field; isolectotypes: L [0057381*], P [01232712*], PRC*, B [200113723*], GH [00135550*].
Voucher: Guadalcanal, 2133 m [7000 ft], 27 Oct 1965, *Braithwaite RSS 4655*, BSIP!, LAE*, P [01222778*].
Note: *Phlegmariurus proliferus* was described from Indonesia and is part of a complex morphological assemblage of plants that is poorly resolved. Six duplicates of the original material matching the protologue are known; we selected the most complete specimen in Blume's herbarium in L as lectotype.

Phlegmariurus squarrosus (G.Forst.) Á.Löve & D.Löve, *Taxon* 26: 324 (1977). E, T
Lycopodium squarrosum G.Forst., *Fl. Ins. Austr.* 86 (1786); *Huperzia squarrosa* (G.Forst.) Trevis., *Atti Soc. Ital. Sci. Nat.* 17(2): 247 (1874); *Urostachys squarrosus* (G.Forst.) Herter, *Bot. Arch.* 3: 14 (1923)
Type: FRENCH POLYNESIA (Tahiti), *Forster s.n.*, lectotype: GOET [012845*], designated by Field (2020); isolectotype: BM [1048443*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10498*, BSIP!, TAIF [519920!], TNM!
Note: Considerable morphological variation is present among plants hitherto identified as *P. squarrosus* from the Solomon Islands, including plants similar to the type as well as plants that appear to be a better match for *P. tafaensis* from New Guinea, which is here regarded as a separate species.

Phlegmariurus tafaensis (Nessel) A.R.Field & C.W.Chen, *comb. nov.* E, B
Urostachys tafaensis Nessel, *Repert. Spec. Nov. Regni Veg.* 39: 61 (1935) [1936]
Type: PAPUA NEW GUINEA, *Brass 4122*, holotype: NY [00127364*]; isotype: BONN-Nessel [328*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11144*, BSIP!, TNM!
Note: This species was misidentified as *P. ignambiensis* (Compton) A.R.Field & Testo in Chen et al. (2017a); it is convergent with that species but differs in its moderately larger size and sparser leaves. *Phlegmariurus tafaensis* is similar to *P. squarrosus* but is more slender and more gracile in all parts. It occurs in eastern New Guinea and the Solomon Islands. It approaches species in the *P. haeckellii–parksii* group but is phylogenetically closer to *P. squarrosus* (Field et al., unpublished data). This species was also named in the same publication as *Urostachys brassii* Nessel from more complete material, but that name is a later homonym of *Urostachys brassii* Copel. The Solomon Island material has longer, sparser leaves than those from the type population in eastern New Guinea.

PSEUDODIPHASIUM Holub, *Folia Geobot. Phytotax.* 18(4): 440 (1983)
Pseudodiphasium volubile (G.Forst.) Holub, *Folia Geobot. Phytotax.* 18(4): 442 (1983). C, K
Lycopodium volubile G.Forst., *Fl. Ins. Austr.* 86 (1786); *Lepidotis volubilis* (G.Forst.) Rothm., *Feddes Repert. Spec. Nov. Regni Veg.* 54: 67 (1944)
Type: PACIFIC ISLANDS, *Forster 319/482*, lectotype: BM [001048401*], designated by Nicolson & Fosberg (2004).

Voucher: Kolombangara, 100–1200 m, 14 Oct 2012, *Chen et al. SITW00833*, BSIP!, TAIF [421216!], TNM!

SELAGINELLACEAE Willk., *Anleit. Stud. Bot.* 2: 163 (1854)
This is a taxonomically difficult family because many diagnostic characters are microscopic. Five species remain unidentified in this checklist. To facilitate the future study of the family in the Solomon Islands, we provide an illustration showing all recognised taxa (Figure 2).

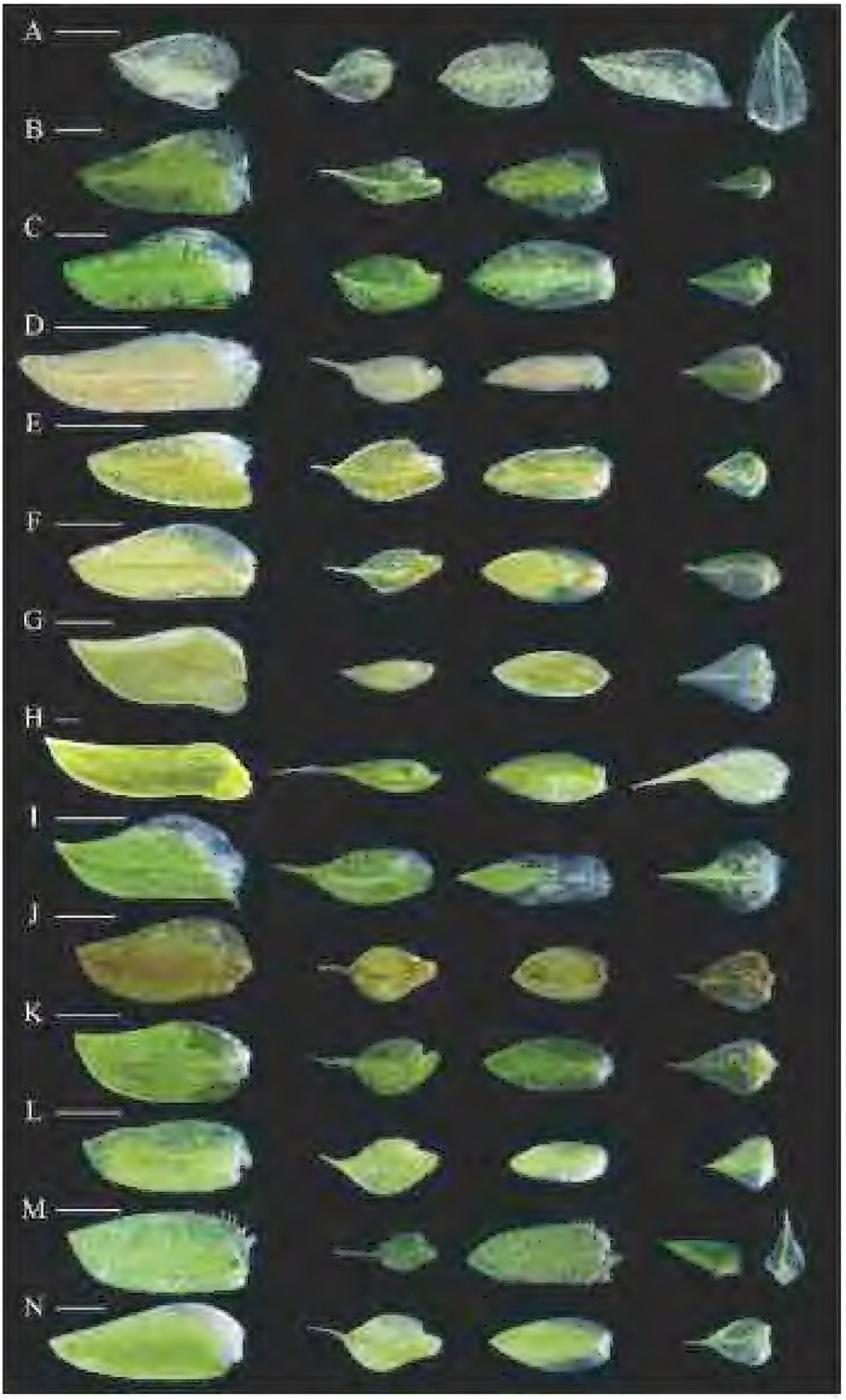
SELAGINELLA P.Beauv., *Mag. Encycl.* 9(5): 478 (1804)
Selaginella ciliaris (Retz.) Spring, *Bull. Acad. Roy. Sci. Bruxelles* 10: 231 (1843). T, S
Lycopodium ciliare Retz., *Observ. Bot.* 5: 32 (1789); *Lycopodioides ciliaris* (Retz.) Kuntze, *Revis. Gen. Pl.* 2: 826 (1891)
Type: SRI LANKA, *König s.n.*, lectotype: LD [1119541*], designated by Alston (1945); isolectotype: K [000009115*].
Voucher: Guadalcanal, 50–150 m, 11 Jul 2016, *Chen et al. SITW11098*, BSIP!, TNM!

Selaginella firmula A.Braun, *Verh. K.K. Zool.-Bot. Ges. Wien* 19: 585 (1869). T, D
Lycopodioides firmula (A.Braun) Kuntze, *Revis. Gen. Pl.* 2: 826 (1891)
Type: PAPUA NEW GUINEA (New Ireland), *Turner s.n.*, lectotypes: B [20 0096740*], designated here by Chen.
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10445*, BSIP!, TAIF [498633!] [519934!], TNM!
Note: Two specimens, *Turner s.n.* and *Herus 10*, were cited in the protologue and both sheets are represented in B with Braun's annotation. We selected the more fully fertile one as the lectotype.

Selaginella kerstingii Hieron., *Bot. Jahrb. Syst.* 50: 2, 21, no. 7 (1913). T, B
Type: PAPUA NEW GUINEA, *Schlechter 17128*, lectotype: B [B 20 0122569*], designated here by Chen; isolectotype: B [20 0122568*] [20 0122570*], BISH [1021066*], BM [001038143*], K [000408398*] [000408399*] [000812129*], L [3498478*] [3498477*], P [00523167*] [00523168*] [00734804*] [P00734805*] [P01467442*], UC [226430*], US [00048942*] [01100955*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11590*, BSIP!, TNM!
Note: Two specimens, *Kersting 2133* and *Schlechter 17128*, were cited in the protologue; we selected one of the more complete specimens in B with Hieronymus' annotation as lectotype. This species was misidentified as *S. breynioides* Baker in Chen et al. (2017a). It has also been confused with *S. latifolia* (Hook. & Grev.) Spring (Henderson & Hancock, 1988).

Selaginella leveriana Alston, *J. Bot.* 77: 225 (1939). T, B
Type: SOLOMON ISLANDS (Makira), *Brass 2702*, holotype: BM [001038171*]; isotype: BRI-AQ [0174534*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10451*, BSIP!, TAIF [519945!] [519946!], TNM!

Selaginella nana (Desv.) Spring, *Bull. Acad. Roy. Sci. Bruxelles* 10: 232 (1843). T, B
Lycopodium nanum Desv., *Encycl. Suppl.* 3: 554 (1814) ['1813']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Type: PAPUA NEW GUINEA (New Ireland), *Commerson s.n.*, lectotype: P [00523190*], designated here by Chen; isolectotype: P [00523058*].
Voucher: Vanikoro, 100–370 m, 24 Jun 2016, *Chen et al. SITW11075*, BSIP!, TNM!
Note: There are two syntypes in P, and we selected the one with more fronds and clearly labelled as collected by Commerson as lectotype.

Selaginella poperangensis Hieron., *Denkschr. Kaiserl. Akad. Wiss., Wien. Math.-Naturwiss. Kl.* 89: 483 (1914). T, B
Type: SOLOMON ISLANDS (Choiseul), *Rechinger 4082*, lectotype: W [1915-0010368*], designated here by Chen; isolectotype: B [20 0096669*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11577*, BSIP!, TNM!
Note: Two duplicates of *Rechinger 4082* are known, and both bear Hieronymus' annotation; we selected the more complete specimen as lectotype.

Selaginella rechingeri Hieron., *Denkschr. Kaiserl. Akad. Wiss., Wien. Math.-Naturwiss. Kl.* 89: 486 (1914). T, D
Type: PAPUA NEW GUINEA (Bougainville), *Rechinger 4715*, lectotype: W [1915-0010366*], designated here by Chen; isolectotype: B [20 0096670*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10439*, BSIP!, TAIF [498637!] [519453!], TNM!
Note: Two specimens, *Rechinger 6666* and *Rechinger 4715*, were cited in the protologue; we selected the more complete specimen as lectotype.

Selaginella schlechteri Hieron., *Bot. Jahrb. Syst.* 50: 2, 41 (1913). T, B
Type: PAPUA NEW GUINEA, *Schlechter 17024*, lectotype: B [20 0096659*], designated here by Chen; isolectotypes: B [20 0096658*], BISH [1000520*] [1017048*] [1017058*], BM [001038144*], L [0057419*], P [00523095*] [00523096*], UC [227273*], US [00048948*] [01101012*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11599*, BSIP!, TNM!
Note: There are two duplicates of *Schlechter 17024* in B, and we selected the one with more strobili.

Selaginella sepikensis Hieron., *Bot. Jahrb. Syst.* 56: 243 (1920). T, D
Type: PAPUA NEW GUINEA, *Ledermann 7052*, lectotype: B [20 0096656*], designated here by Chen; isolectotypes: B [20 0096657*], BM [001038149*].

Figure 2. (Opposite page) *Selaginella* of the Solomon Islands. A. *S. ciliaris* (Retz.) Spring (*Chen et al. SITW06894*). B. *S. firmula* A.Braun (*Chen et al. SITW10445*). C. *S. kerstingii* Hieron. (*Chen et al. SITW05757*). D. *S. leveriana* Alston (*Chen et al. SITW05278*). E. *S. nana* (Desv.) Spring (*Chen et al. SITW10559*). F. *S. poperangensis* Hieron. (*Chen et al. SITW01616*). G. *S. rechingeri* Hieron. (*Chang et al. SITW08554*). H. *S. schlechteri* Hieron. (*Hung et al. SITW09775*). I. *S. sepikensis* Hieron. (*Chen et al. SITW5764*). J. *S. whitmeei* Baker (*Chen et al. SITW10449*). K. *Selaginella* sp. 1 (*Chen et al. SITW10541*). L. *Selaginella* sp. 2 (*Chen et al. SITW11181*). M. *Selaginella* sp. 3 (*Chen et al. SITW05761*). N. *Selaginella* sp. 4 (*Chen et al. SITW05658*). For each species, a dorsal leaf, a ventral leaf, an axillary leaf, and a sporophyll (or sporophylls when dimorphic) are illustrated. Scale bars = 1 mm. Photographed by C.-W. Chen.

Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10493*, BSIP!, TAIF [519928!], TNM!
Note: Three duplicates of *Ledermann 7052* are known, and two of them in B bear Hieronymus' annotation; we selected the one with more plants as lectotype.

Selaginella whitmeei Baker, *J. Bot.* 23: 24 (1885). T, D
Type: SAMOA, *Whitmee 177*, lectotype: K [001067519], designated here by Chen.
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10449*, BSIP!, TAIF [498627!] [519940!] [519941!], TNM!
Note: Two specimens, *Whitmee 177* and *Whitmee 221*, were cited in the protologue; we selected the one with larger plants and more fronds as lectotype.

***Selaginella* sp. 1.** T
Voucher: Vanikoro, 70 m, 26 Jun 2016, *Chen et al. SITW11082*, BSIP!, TNM!
Note: This species was unidentified in Chen et al. (2017a: 72–73). Morphologically, it is almost identical to *S. leveriana*, except it has glabrous stems.

***Selaginella* sp. 2.** T
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11181*, BSIP!, TAIF [498943!] [498944!], TNM!
Note: This species was misidentified as *S. birarensis* Kuhn in Chen et al. (2017a). It differs from *S. birarensis* by having toothed leaves (vs. ciliate).

***Selaginella* sp. 3.** T
Voucher: Guadalcanal, 100–500 m, 24 Jul 2014, *Chen et al. SITW05761*, BSIP!, TAIF [472275!], TNM!
Note: This species is morphologically similar to *S. nana* but differs by having dimorphic sporophylls.

***Selaginella* sp. 4.** T
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05658*, BSIP!, TAIF [473045!], TNM!
Note: This species is characterised by its erect habit, entire leaves and aristate ventral leaves.

EQUISETACEAE Michx. ex DC., *Essai Propr. Méd.* pl. 49 (1804)
EQUISETUM L., *Sp. Pl.* 2: 1061 (1753)
Equisetum ramosissimum Desf. var. ***huegelii*** (Milde) Christenh. & Husby, *Bot. J. Linn. Soc.* 189(4): 343 (2019). T, T
Equisetum huegelii Milde, *Verh. K.K. Zool.-Bot. Ges. Wien* 11: 356 (1861)
Type: INDIA, *Hügel 1021*, lectotype: W [0030967*], designated by Christenhusz et al. (2019); isolectotypes: FR [0031256] [0031257].
Voucher: Guadalcanal, 50–300 m, 13 Jul 2016, *Chen et al. SITW11119*, BSIP!, TAIF!, TNM!
Note: This taxon has been more widely known as *Equisetum ramosissimum* subsp. *debile* (Roxb. ex Vaucher) Hauke; here we follow Christenhusz et al. (2019), who recognised it at varietal rank.

PSILOTACEAE J.W.Griff. & Henfr., *Microgr. Dct.* 540 (1855)
PSILOTUM Sw., *J. Bot. (Schrader)* 1800(2): 8, 109 (1801)
Psilotum complanatum Sw., *J. Bot. (Schrader)* 1800(2): 8, 110 (1801). E, T
Type: JAMAICA, *s.c., s.n.,* lectotype: B-W [19437-010*], designated by Chinnock (1998).
Voucher: Vanikoro, 120–600 m, 17 Jul 2016, *Chen et al. SITW10570*, BSIP!, TAIF [520564!], TNM!

Psilotum nudum (L.) P.Beauv., *Prodr. Aethéogam.* 112 (1805). E, T
Lycopodium nudum L., *Sp. Pl.* 2: 1100 (1753).
Type: INDIA, *s.c., s.n.*, lectotype: LINN-HL [1257.1*], designated by Proctor (1977).
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10543*, BSIP!, TAIF [519869!], TNM!

TMESIPTERIS Bernh., *J. Bot. (Schrader)* 1800 (2): 8, 131 (1801)
Tmesipteris oblanceolata Copel., *Philipp. J. Sci.* 60: 99. (1936). T, D
Type: SOLOMON ISLANDS (Guadalcanal), *Kajewski 2632*, holotype: PNH, destroyed; lectotype: MICH [1191058*], designated here by Chen; isolectotypes: BISH [1000596*], MEL [2302978*].
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04923*, BSIP!, TAIF [463834!], TNM!
Note: The holotype in PNH (Copeland 1936) was destroyed; we selected the duplicate from Copeland's private herbarium (now in MICH) as lectotype.

Tmesipteris ovata N.A.Wakef., *Victorian Naturalist* 60: 143 (1944). E, J
Type: AUSTRALIA, *Wakefield 374*, holotype: MEL [1509475*]; isotypes: MEL [52425], NSW [638821].
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04922*, BSIP!, TAIF [463835!], TNM!

Tmesipteris solomonensis Braithwaite, *Brit. Fern Gaz.* 10: 302 (1973). E, A
Type: SOLOMON ISLANDS (Guadalcanal), *Braithwaite RSS 4824*, holotype: BM [001038003]; isotypes: BSIP!, K [001057667*].
Voucher: Kolombangara, 1000–1200 m, 15 Oct 2012, *Chen et al. SITW01032*, BSIP!, TAIF [421251!], TNM!
Note: Endemic.

OPHIOGLOSSACEAE Martinov, *Tekhno-Bot. Slovar.* 438 (1820)
HELMINTHOSTACHYS Kaulf., *Enum. Filic.* 28 (1824)
Helminthostachys zeylanica (L.) Hook., *Gen. Fil.* t. 47 (1840). T, T
Osmunda zeylanica L., *Sp. Pl.* 2: 1063 (1753)
Type: SRI LANKA, holotype: BM [000621045*, an illustration].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10533*, BSIP!, TAIF [520614!] [520615!] [520616!], TNM!
Note: Linnaeus (1753) clearly referred to his earlier book *Flora Zeylanica* (1747), where he first described the species based on Hermann's illustration [Inter pictas Hermanni planta est]. Hermann's illustration in BM bears the entry 373 used in Linnaeus' *Flora Zeylanica*, and we consider this as the holotype. Previous studies (e.g., Fraser-Jenkins et

al., 2017; Field, 2020) erroneously considered van Oostroom (1937) as the place of lectotypification for *O. zeylanica*. In that work, van Oostroom (1937) merely cited a specimen of *O. zeylanica* in L collected by Rumphius (from Indonesia) and annotated by Hermann as '*Ophioglossum laciniatum* Rumph.' However, van Oostroom did not attempt a lectotypification.

OPHIODERMA (Blume) Endl., *Gen. Pl.* 66 (1836)
Ophioderma falcatum (C.Presl) O.Deg., *Fl. Hawaiiensis* (1932). T, I
Ophioderma pendulum var. *falcatum* C.Presl, *Suppl. Tent. Pterid.* 56 (1845); *Ophioglossum pendulum* subsp. *falcatum* (C.Presl) R.T.Clausen, *Mem. Torrey Bot. Club* 19(2): 117 (1938)
Type: PHILIPPINES (Luzon), *Cuming 91*, lectotype: PRC*, designated here by Chen.
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04905*, BSIP!, TAIF [463848!], TNM!
Note: Presl (1845) listed three collections including *Macrae s.n.* from Woahu [Oahu], *Neson s.n.* from Owyhi [Hawai'i], and *Cuming 91* from Luzon. We found only *Cuming 91* in Presl's herbarium (now in PRC) and thus selected it as lectotype. The phylogenetic analysis of Zhang et al. (2020) showed that there are two deeply diverged clades within *Ophioderma* and suggested the presence of cryptic species. We tentatively accept *O. falcatum* as a different species, but further study is needed to clarify its relationship to *O. pendulum*.

Ophioderma pendulum (L.) Endl., *Gen. Pl.* 66 (1836). E, T
Ophioglossum pendulum L., *Sp. Pl.*, ed. 2, 2: 1518 (1763)
Type: INDONESIA (Maluku, Ambon), *s.c., s.n.*, lectotype: Rumphius, *Herb. Amboin.*, 6: t. 37, f. 3 (1750), designated by Green (1988).
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10517*, BSIP!, TAIF [519868!], TNM!

OPHIOGLOSSUM L., *Sp. Pl.* 2: 1062 (1753)
Ophioglossum lineare Schltr. & Brause, *Bot. Jahrb. Syst.* 49: 59 (1912). T, B
Type: PAPUA NEW GUINEA (New Ireland), *Schlechter 14634*, not found.
Voucher: Vella Lavella, 312–775 m, 28 Oct 2013, *Chen et al. SITW04032*, BSIP!, TAIF [459757!], TNM!
Note: According to Taxonomic Literature II, the specimens and types of both Schlechter and Brause are kept in B. However, no original material has been located there (Zimmer pers. comm.).

Ophioglossum parvifolium Hook. & Grev., *Bot. Misc.* 3: 218 (1833). T, T
Type: INDIA (Gujarat), *Patil & Kachhiyapatel 38*, holotype: BARO [123450070019], *typ. cons. prop.*
Voucher: Rennell, 20–50 m, 3 Jul 2014, *Chen et al. SITW05325*, BSIP!, TAIF [471771!], TNM!
Note: This name has usually been synonymised under *O. nudicaule* L.f. and was tentatively used in Chen et al. (2017a); here we follow Fraser-Jenkins (2008) who recognised *O. parvifolium* as a distinct species. Fraser-Jenkins (2008) distinguished *O. parvifolium* by smaller plant size and rounded sterile fronds that often lie flat on the ground; these characters match well populations in the Solomon Islands. However, after

seeing an image of the type (K000740336*), Mazumdar et al. (2018) found that the type of *O. parvifolium* looks identical to *O. costatum* R.Br., and therefore is a synonym of it. In order to continue to use the name *O. parvifolium* sensu Fraser-Jenkins (2008), Mazumdar et al. (2018) proposed to conserve this species with a newly collected conserved type. In case this proposal is rejected, the earliest synonym listed by Fraser-Jenkins (2008), *Ophioglossum macrorrhizum* Kunze, should be used for this species.

Ophioglossum reticulatum L., *Sp. Pl.* 2: 1063 (1753). T, T
Type: HAITI (Fond de Baudin), lectotype: Plumier, *Traité foug. Amér.* t. 164 (1705), designated by Tardieu-Blot (1964).
Voucher: Vangunu, 70–320 m, 5 Oct 2013, *Chen et al. SITW03695*, BSIP!, TAIF [451696!], TNM!
Note: The current species circumscription is very broad, and further study is needed to confirm if the Solomon Islands plants are identical to those from the type locality.

MARATTIACEAE Kaulf., *Enum. Filic.* 31 (1824)
ANGIOPTERIS Hoffm., *Commentat. Soc. Regiae Sci. Gott.* 12: 29 (1796)
Angiopteris microura Copel., *Philipp. J. Sci.* 60: 101, t.4 (1936). T, D
Type: SOLOMON ISLANDS (Makira), *Brass 2711*, holotype: PNH, destroyed; lectotype: MICH [1003396A*] [1003396B*], designated here by Murdock; isolectotypes: BM [000787102!] [000016703!] [000016704!], BRI-AQ [0143017*], GH [00020474!], L [0053632!], UC [574162!], US [0048651!].
Voucher: Malaita, 150–350 m, 22 Jul 2015, *Chen et al. SITW07661*, BSIP!, TAIF [486577!], TNM!, VT [284021!].
Note: The holotype in PNH (Copeland 1936) was destroyed, and we selected two sheets of *Brass 2711* from Copeland's herbarium (now in MICH) as lectotype. They are clearly labelled as being part of a single specimen, in accordance with ICN Art. 8.3 (Turland et al., 2018).

CHRISTENSENIA Maxon, *Proc. Biol. Soc. Wash.* 18: 239 (1905)
Christensenia aesculifolia (Blume) Maxon, *Proc. Biol. Soc. Wash.* 18: 240 (1905). T, P
Aspidium aesculifolium Blume, *Enum. Pl. Javae* 2: 143 (1828), *nom. inval.*; *Kaulfussia aesculifolia* Blume, *Enum. Pl. Javae* 2: 260 (1828)
Type: INDONESIA (Java), *Zippelius s.n.* "Jassinga [Jasinga] et Tjiminjak," lectotype: L [0051148*], designated here by Murdock.
Voucher: Malaita, 150–350 m, 22 Jul 2015, *Chen et al. SITW07910*, BSIP!, TAIF [487539!], TNM!
Note: Blume would have had access to multiple specimens, which are still in the collection at L. The specimen selected as lectotype bears Blume's handwriting with the note "Nov genus filicum" and a small sketch of the distinctive circular synangium.

PTISANA Murdock, *Taxon* 57(3): 744 (2008)
Ptisana ambulans Murdock & C.W.Chen, *PhytoKeys* 170: 8 (2020). T, A
Type: SOLOMON ISLANDS (New Georgia), *Chen et al. SITW00629*, holotype: BSIP; isotypes: TAIF [421080!], TNM!
Note: Endemic and known only from the type collection.

Ptisana decipiens Murdock & C.W.Chen var. ***decipiens***, *PhytoKeys* 170: 10 (2020). T, B

Type: SOLOMON ISLANDS (Guadalcanal*), Chen et al. SITW00130*, holotype: BSIP; isotypes: TAIF [417070!] [417072!], TNM!
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11139*, BSIP!, TAIF!, TNM!
Note: This species was misidentified as *P. ternatea* (de Vriese) Murdock in Chen et al. (2017a); see Murdock et al. (2020) for further details.

Ptisana decipiens Murdock & C.W.Chen var. ***delicata*** Murdock & C.W. Chen, *PhytoKeys* 170: 13 (2020). T, B
Type: SOLOMON ISLANDS (Santa Isabel), *Chen et al. SITW05642*, holotype: BSIP; isotypes: TAIF [473020!] [473021!], TNM!
Voucher: Vangunu, 70–320 m, 5 Oct 2013, *Chen et al. SITW03734*, BSIP!, TAIF [451625!], TNM!
Note: This species was misidentified as *P. ternatea* (de Vriese) Murdock in Chen et al. (2017a). The photos of a plant with smaller ultimate segments in Chen et al. (2017a: 95) belong here; see Murdock et al. (2020) for further details.

Ptisana papuana (Alderw.) Murdock & C.W.Chen, *PhytoKeys* 170: 14 (2020). T, B
Marattia papuana Alderw., *Bull. Jard. Bot. Buitenzorg*, ser. 2, 23: 17 (1916)
Type: INDONESIA (Indonesian New Guinea), *Hollrung 613*, holotype: BO; isotype: BM [000787141!].
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04892*, BSIP!, TAIF [465293!], TNM!
Note: The photographs of *P. smithii* from high mountains in Chen et al. (2017a) are of this species; see Murdock et al. (2020) for further details.

Ptisana smithii (Mett. ex Kuhn) Murdock, *Taxon* 57(3): 748 (2008). T, C
Marattia smithii Mett. ex Kuhn, *Verh. K.K. Zool.-Bot. Ges. Wien* 19: 584 (1869)
Type: VANUATU, *Herus 5*, lectotype: P [00522670!], designated by Murdock (2008); isolectotype: GH [00311048!].
Voucher: Vanikoro, 20–250 m, 20 Jun 2016, *Chen et al. SITW11037*, BSIP!, TAIF [498870!] [498871!] [498872!] [498873!] [498874!], TNM!
Note: Brownlie (1977) cited a type from B, however, no original material has been located there (Zimmer pers. comm.).

OSMUNDACEAE Martinov, *Tekhno-Bot. Slovar* 445 (1820)
LEPTOPTERIS C.Presl, *Suppl. Tent. Pterid.* 70 (1845)
Leptopteris laxa Copel., *Philipp. J. Sci.* 60: 101, t.5 (1936). TF, B
Type: PAPUA NEW GUINEA (Bougainville), *Kajewski 1737*, holotype: PNH, destroyed; lectotype: MICH [1190698*], designated here by Chen; isolectotypes: BRI-AQ [0171258], GH [00021495*] [00021496*], L [0051778], P [00523206*], UC [574165*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07548*, BSIP!, TAIF [487345!], TNM!, VT [284058!].
Note: The holotype deposited in PNH (Copeland 1936) was destroyed; we selected the isotype from Copeland's personal herbarium (now in MICH) as lectotype.

HYMENOPHYLLACEAE Mart., *Consp. Regn. Veg.* 3 (1835)
ABRODICTYUM C.Presl, *Hymenophyllaceae* 20 (1843)

Abrodictyum asae-grayi (Bosch) Ebihara & K.Iwats., *Blumea* 51(2): 243 (2006). E, F
Trichomanes asae-grayi Bosch, *Ned. Kruidk. Arch*. 5(2): 180 (1861); *Macroglena asae-grayi* (Bosch) Copel., *Philipp. J. Sci*. 67: 84 (1938)
Type: FIJI, *Wilkes Explor. Exped. 21*, syntypes: P [00718325*], US [00134585*].
Voucher: Vanikoro, 420–780 m, 18 Jun 2016, *Chen et al. SITW11007*, BSIP!, TAIF [498888!] [498889!], TNM!
Note: Two duplicates of *Wilkes Explor. Exped. 21* are known, but none of them bear Bosch's annotation; we therefore do not make a lectotypification.

Abrodictyum caudatum (Brack.) Ebihara & K.Iwats., *Blumea* 51(2): 243 (2006). E, J
Trichomanes caudatum Brack., *U.S. Expl. Exped., Filic*. 16: 256, t.36, f.5 (1854); *Macroglena caudata* (Brack.) Copel., *Philipp. J. Sci*. 67: 84 (1938); *Cephalomanes caudatum* (Brack.) Bostock, *Fl. Australia* 48: 706 (1998)
Type: FRENCH POLYNESIA (Tahiti), *Wilkes Explor. Exped. 15*, lectotype: US [00134593*], designated by Croxall (1975); isotype: MICH [1191462*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11673*, BSIP!, TAIF [498905!], TNM!

Abrodictyum cumingii C.Presl, *Hymenophyllaceae* 20, t.7 (1843). E, P
Habrodictyon cumingii (C.Presl) Bosch, *Hymenophyll. Javan.* 17, t. 12 (1861); *Trichomanes cumingii* (C.Presl) C.Chr., *Index Filic*. 638 (1906); *Cephalomanes cumingii* (Presl) K.Iwats., *Acta Phytotax. Geobot*. 35(4-6): 176 (1984)
Type: PHILIPPINES (Luzon), *Cuming 208*, lectotype: PRC, designated by Iwatsuki & Ebihara (2022); isolectotypes: E [00417494*] [00509045*], GOET [009204*], K [000375522*], MICH [1190000*], US [00134598*].
Voucher: Guadalcanal, 1100–1300 m, 16 Sep 2015, *Chen et al. SITW09840*, BSIP!, TAIF [516249!], TNM!

Abrodictyum flavofuscum (Bosch) Ebihara & K.Iwats., *Blumea* 51(2): 243 (2006). E, D
Trichomanes flavofuscum Bosch, *Ann. Sci. Nat., Bot*., sér. 4, 15: 88 (1861); *Macroglena flavofusca* (Bosch) Copel., *Philipp. J. Sci*. 67: 84 (1938)
Type: NEW CALEDONIA, *Vieillard 1655*, lectotype: P [00624453*], designated by Brownlie (1969); isolectotypes: GH [00022234*], P [00624452*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11672*, BSIP!, TAIF [498906!], TNM!

Abrodictyum obscurum (Blume) Ebihara & K.Iwats., *Blumea* 51(2): 244 (2006). T, S
Trichomanes obscurum Blume, *Enum. Pl. Javae* 2: 227 (1828); *Selenodesmium obscurum* (Blume) Copel., *Philipp. J. Sci*. 67: 81 (1938); *Cephalomanes obscurum* (Blume) K.Iwats., *J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot*. 13: 547 (1985)
Type: INDONESIA (Java), *Zippelius s.n*., lectotype: L, designated by Morton (1974); isolectotypes: L [0063036*] [0063037*] [0544609*].
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10587*, BSIP!, TAIF [520527!], TNM!

Abrodictyum pluma (Hook.) Ebihara & K.Iwats., *Blumea* 51(2): 243 (2006). T, N
Trichomanes pluma Hook., *Icon. Pl*. 6: t.997 (1854)

Type: MALAYSIA (Borneo), *Lobb s.n.*, holotype: K [000361948*].
Voucher: Vanikoro, 420–780 m, 18 Jun 2016, *Chen et al. SITW11006*, BSIP!, TAIF [498890!], TNM!

Abrodictyum schlechteri (Brause) Ebihara & K.Iwats., *Blumea* 51(2): 243 (2006). E, E
Trichomanes schlechteri Brause, *Bot. Jahrb. Syst.* 49: 10 (1912); *Macroglena schlechteri* (Brause) Copel., *Philipp. J. Sci.* 67: 84 (1938)
Type: PAPUA NEW GUINEA, *Schlechter 19612*, lectotype: B [20 0106769*], designated by Iwatsuki & Ebihara (2022); isolectotypes: B [20 0106770*], E [00417492*], K [000377067*] [001090239*], L [0052387*] [0052388*] [0052389*], P [00624474*] [00624475*] [00624476*], UC [1576965*], US [00048811*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11659*, BSIP!, TAIF [498913!], TNM!

CALLISTOPTERIS Copel., *Occas. Pap. Bernice Pauahi Bishop Mus.* 14(2): 49 (1938)
Callistopteris apiifolia (C.Presl) Copel., *Philipp. J. Sci.* 67: 65 (1938). E, R
Trichomanes apiifolium C.Presl, *Hymenophyllaceae* 16, 44 (1843); *Cephalomanes apiifolium* (C.Presl) K.Iwats., *Acta Phytotax. Geobot.* 35(4-6): 176 (1984)
Type: PHILIPPINES (Luzon), *Cuming 137*, lectotype: PRC, designated by Iwatsuki & Ebihara (2022); isolectotypes: E [00417487*] [00417490], G [00348928], GH [00022197*], K [000375332*], MICH [13110058], W [0052571*].
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10568*, BSIP!, TAIF [520576!], TNM!

CEPHALOMANES C.Presl, *Hymenophyllaceae* 17 (1843)
Cephalomanes atrovirens C.Presl f. ***atrovirens***, *Hymenophyllaceae* 18, t.5 (1843). T, O
Trichomanes atrovirens (C.Presl) Kunze, *Bot. Zeitung (Berlin)* 5: 371 (1847)
Type: PHILIPPINES (Luzon), *Cuming 169*, lectotype: PRC, designated by Croxall (1975); isolectotypes: E [00413871*] [00413873*], GH [00020718*], GOET [009200*], K [000375661*], L [3517156*] [3517155*], MICH [1190162*], P [00624501*] [00624502*] [00624503*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10460*, BSIP!, TAIF [464206!], TNM!

Cephalomanes atrovirens C.Presl f. ***acrosorum*** (Copel.) K.Iwats., *J. Jap. Bot.* 66(3): 141 (1991). T, F
Trichomanes acrosorum Copel., *Philipp. J. Sci., C.* 6: 72 (1911); *Cephalomanes acrosorum* (Copel.) Copel., *Philipp. J. Sci.* 67: 68 (1938)
Type: PAPUA NEW GUINEA, *King 352*, holotype: MICH [1191059*].
Voucher: Rendova, 0–100 m, 29 Aug 2013, *Chen et al. SITW03583*, BSIP!, TAIF [448548!], TNM!
Note: This species was treated as *C. acrosorum* (Copel.) Copel. in Chen et al. (2017a), but here we follow the taxonomic revision of Iwatsuki (1991) who treated it as a form of *C. atrovirens*.

Cephalomanes densinervium (Copel.) Copel., *Philipp. J. Sci.* 67: 67 (1938). T, F
Trichomanes densinervium Copel., *Philipp. J. Sci., C.* 6: 71 (1911)
Type: PAPUA NEW GUINEA, *King 150*, holotype: MICH [1191066*].

Voucher: Santa Isabel, 0 m, 2 Oct 1965, *Braithwaite RSS 4592*, BSIP!

Cephalomanes javanicum (Blume) C.Presl var. ***asplenioides*** (C.Presl) K.Iwats., *J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot.* 13(5): 549, 548 (1985). T, P
Trichomanes asplenioides C.Presl, *Hymenophyllaceae* 15, 37 (1843), *non* Sw., *Prodr.* 136 (1788); *Cephalomanes asplenioides* C.Presl, *Abh. Königl. Böhm. Ges. Wiss.* 5(5): 334 (1848)
Type: PHILIPPINES, *Cuming 184*, lectotype: PRC, designated by Morton (1974); isolectotypes: E [00413868*] [00413869*], GH [00022199*], GOET [009199*], K [000375462*], L [0544639*] [0544640*], P [00624440*] [00624441*], US [00134586*].
Voucher: Kolombangara, 200 m, 3 Apr 2017, *Hsu et al. SITW 13188*, BSIP!, TNM!

CREPIDOMANES C.Presl, *Epimel. Bot.* 258 (1851 ['1849'])
Crepidomanes aphlebioides (Christ) I.M.Turner, *Asian J. Trop. Biol.* 1(2): 26 (1995). E, K
Trichomanes tenuissimum Christ, *Fl. Schutzgeb. Südsee* 106 (1901), *non* Bosch, *Ned. Kruidk. Arch.* 5(2): 156 (1861); *Trichomanes aphlebioides* C.Chr., *Index Filic.* 635 (1906); *Vandenboschia aphlebioides* (C.Chr.) Copel., *Philipp. J. Sci.* 67: 54 (1938)
Type: PAPUA NEW GUINEA, *Lauterbach 494*, holotype: P [00624506*]; isotype: L [0544635*].
Voucher: Malaita, 150–350 m, 22 Jul 2015, *Chen et al. SITW07649*, BSIP!, TAIF [486630!], TNM!

Crepidomanes bipunctatum (Poir.) Copel., *Philipp. J. Sci.* 67: 59 (1938). E, T
Trichomanes bipunctatum Poir., *Encycl.* 8: 69 (1808); *Didymoglossum bipunctatum* (Poir.) E.Fourn., *Ann. Sci. Nat., Bot.,* sér. 5, 18: 263 (1873)
Type: MADAGASCAR, *Petit-Thouars s.n.*, holotype: P [00477823*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10479*, BSIP!, TAIF [519950!], TNM!

Crepidomanes humile (G.Forst.) Bosch, *Hymenophyll. Javan.* 16, t.11 (1861). R, S
Trichomanes humile G.Forst., *Fl. Ins. Austr.* 84 (1786); *Didymoglossum humile* (G.Forst.) C.Presl, *Hymenophyllaceae* 3 (1843); *Crepidopteris humilis* (G.Forst.) Copel., *Philipp. J. Sci.* 67: 58 (1938); *Crepidophyllum humile* (G.Forst.) C.F.Reed, *Amer. Fern J.* 38: 89 (1948); *Reediella humilis* (G.Forst.) Pic.Serm., *Webbia* 24: 719 (1970)
Type: FRENCH POLYNESIA (Society Isl.), *Forster s.n.*, lectotype: K, designated by Nicolson & Fosberg (2004).
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10514*, BSIP!, TAIF [519873!], TNM!

Crepidomanes intermedium (Bosch) Ebihara & K.Iwats., *Blumea* 51(2): 240 (2006). R, D
Trichomanes intermedium Bosch, *Ned. Kruidk. Arch.* 5(2): 179 (1861); *Nesopteris intermedia* (Bosch) Copel., *Philipp. J. Sci.* 67: 66 (1938)
Type: FIJI (Ovalau), *Wilkes Explor. Exped. 18*, lectotype: L [0544658*], designated by Iwatsuki & Ebihara (2022); isolectotypes: GH [00139590*] [00022243*], P [00624415*] [00624416*], US [00134609*].
Voucher: Makira, 910 m, 1 Jul 2015, *Chen et al. SITW06918*, BSIP!, TAIF [482842!],

TNM!

Crepidomanes kurzii (Bedd.) Tagawa & K.Iwats., *Acta Phytotax. Geobot.* 26(5-6): 169 (1975). R, S
Trichomanes kurzii Bedd., *Ferns Brit. Ind.* 2: t. 286 (1868); *Hymenophyllum kurzii* (Bedd.) Prantl, *Unters. Morph. Gefasskrypt.* 54 (1875)
Type: INDIA (South Andaman Island), *Kurz s.n.*, lectotype: BM, designated by Croxall (1975); isolectotype: K [001090179*].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10560*, BSIP!, TAIF [520581!], TNM!

Crepidomanes minutum (Blume) K.Iwats., *J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot.* 13(5): 524 (1985). E, T
Trichomanes minutum Blume, *Enum. Pl. Javae* 2: 223 (1828); *Gonocormus minutus* (Blume) Bosch, *Hymenophyll. Javan.* 7, t.3 (1861); *Trichomanes proliferum* Blume var. *minutum* (Blume) C.A.Hameed, K.P.Rajesh & Madhus., *Filmy Ferns S. India* 258 (2003); *Crepidomanes proliferum* var. *minutum* (Blume) C.A.Hameed ex Easa, *Biodivers. Doc. Kerala, Part 5: Pteridophytes* 42 (2003)
Type: INDONESIA (Java), lectotype: *Blume s.n.*, L [0544607*], designated by Croxall (1975).
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07600*, BSIP!, TAIF [486587!], TNM!
Note: As defined in Nitta et al. (2011), this species is a complex; it includes *C. minutum*, *C. saxifragoides* (C.Presl) P.S.Green, and *Crepidomanes* sp., as illustrated in Chen et al. (2017a).

Crepidomanes vitiense (Baker) Bostock, *Fl. Australia* 48: 706 (1998). R, S
Trichomanes vitiense Baker, *J. Linn. Soc., Bot.* 9: 338, t. 8, f. D (1866); *Microtrichomanes vitiense* (Baker) Copel., *Philipp. J. Sci.* 67: 37 (1938)
Type: FIJI, *Milne s.n.*, holotype: K [000755401*].
Voucher: Guadalcanal, 100–500 m, 27 Jul 2014, *Chen et al. SITW05787*, BSIP!, TAIF [472250!], TNM!

DIDYMOGLOSSUM Desv., *Mém. Soc. Linn. Paris* 6: 330 (1827)
Didymoglossum beccarianum (Ces.) Senterre & Rouhan, *Phytotaxa* 292(3): 210 (2017). E, S
Trichomanes beccarianum Ces., *Atti Reale Accad. Sci. Fis.* 7(8): 8, t. 1, f. 2 (1876); *Microgonium beccarianum* (Ces.) Copel., *Philipp. J. Sci.* 67: 63 (1938)
Type: MALAYSIA (Sarawak), *Beccari s.n.*, lectotype: RO, designated by Croxall (1975); isolectotypes: FI [013661*], isotypes: K [000362070*] [000362071*], BM [001019579*].
Voucher: Vangunu, 70–320 m, 5 Oct 2013, *Chen et al. SITW03804*, BSIP!, TAIF [451661!], TNM!

Didymoglossum mindorense (Christ) K.Iwats., *Blumea* 51(2): 236 (2006). E, O
Trichomanes mindorense Christ, *Philipp. J. Sci., C.* 3: 270 (1908); *Microgonium mindorense* (Christ) Copel., *Philipp. J. Sci.* 67: 61 (1938)
Type: PHILIPPINES (Mindoro), *Merrill 6066*, lectotype: P [00624464*], designated by

Croxall (1975); isolectotypes: GH [00022253*], MICH [1191083*], US [00134614*].
Voucher: Vanikoro, 20–150 m, 21 Jun 2016, *Chen et al. SITW11055*, BSIP!, TNM!

Didymoglossum tahitense (Nadeaud) Ebihara & K.Iwats., *Blumea* 51(2): 236 (2006). E, S
Trichomanes tahitense Nadeaud, *Énum. Pl. Tahiti* 18 (1873); *Microgonium tahitense* (Nadeaud) Tindale, *Contr. New South Wales Natl. Herb., Fl. Ser.* 201: 4 (1963)
Type: FRENCH POLYNESIA (Tahiti), *Nadeaud s.n.*, holotype: P.
Voucher: Vanikoro, 20–150 m, 21 Jun 2016, *Chen et al. SITW11056*, BSIP!, TNM!

HYMENOPHYLLUM Sm., *Mém, Acad. Roy. Sci. (Turin)* 5: 418, pl. 9, f. 8 (1793)
Hymenophyllum angulosum Christ, *Philipp. J. Sci., C.* 3: 269 (1908). E, I
Mecodium angulosum (Christ) Copel., *Philipp. J. Sci.* 67: 20 (1938)
Type: PHILIPPINES (Mindoro), *Merrill 6080*, lectotype: P [00622001*], designated by Iwatsuki & Ebihara (2022); isolectotypes: P [00622002*], MICH [1190631*], NY [00688637*], US [00134544*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11677*, BSIP!, TNM!

Hymenophyllum brassii C.Chr., *Brittonia* 2: 273 (1937). E, B
Meringium brassii (C.Chr.) Copel., *Philipp. J. Sci.* 73: 463 (1941); *Myriodon brassii* (C.Chr.) Copel., *Ann. Cryptog. Phytopathol.* 5: 36 [*Gen. Fil.*] (1947)
Type: PAPUA NEW GUINEA, *Brass 4114*, lectotype: BM [001044219*], designated by Iwatsuki & Ebihara (2022); isolectotypes: GH [00055018*], MICH [1190637*], NY [00127536*], BRI-AQ [0024734*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07601*, BSIP!, TNM!

Hymenophyllum copelandii C.V.Morton, *Contr. U.S. Natl. Herb.* 38: 173 (1968). E, B
Mecodium archboldii Copel., *Philipp. J. Sci.* 73: 458, t.1 (1941)
Type: INDONESIA (Indonesian New Guinea), *Brass 14067*, lectotype: MICH [1190737*], designated by Iwatsuki & Ebihara (2022); isolectotypes: BM [001044215*], BRI-AQ [0148061*], FI [004042*], K [000421527*], L [0051708*] [0062258*], UC [632604*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11192*, BSIP!, TNM!
Note: *Hymenophyllum copelandii* is a new name for *Mecodium archboldii* because the latter is blocked by *Hymenophyllum archboldii* (Copel.) C.V.Morton, when treated in *Hymenophyllum*.

Hymenophyllum digitatum (Sw.) Fosberg, *Smithsonian Contr. Bot.* 45: 1 (1980). E, T
Trichomanes digitatum Sw., *Syn. Fil.* 370, 422 (1806); *Microtrichomanes digitatum* (Sw.) Copel., *Philipp. J. Sci.* 67: 36 (1938); *Gonocormus digitatus* (Sw.) Prantl, *Unters. Morph. Gefasskrypt.* 51 (1875); *Crepidomanes digitatum* (Sw.) K.Iwats., *Acta Phytotax. Geobot.* 35: 175 (1984)
Type: MAURITIUS/ RÉUNION, *s.c., s.n.*, possible types: P [00064999*], S-P [5176].
Voucher: Vanikoro, 420–780 m, 18 Jun 2016, *Chen et al. SITW11005*, BSIP!, TNM!

Hymenophyllum gorgoneum Copel., *Philipp. J. Sci.* 64: 60, t.26 (1937). E, B
Meringium gorgoneum (Copel.) Copel., *Philipp. J. Sci.* 67: 44 (1938)
Type: SOLOMON ISLANDS (Santa Isabel), *Brass 3304*, lectotype: MICH [1190646*],

designated by Ebihara & Iwatsuki (2010); isolectotypes: BRI-AQ [0148258*], GH [00021356*], UC [542101*].
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04935*, BSIP!, TAIF [463825!], TNM!

Hymenophyllum holochilum (Bosch) C.Chr., *Index Filic*. 362 (1905). E, S
Didymoglossum holochilum Bosch, *Pl. Jungh*. 561 (1857); *Meringium holochilum* (Bosch) Copel., *Philipp. J. Sci*. 67: 41 (1938); *Leptocionium holochilum* (Bosch) Bosch, *Ned. Kruidk. Arch*. 4(4): 383 (1859)
Type: INDONESIA (Java), *Hasskarl s.n*., holotype: L.
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07599*, BSIP!, TNM!

Hymenophyllum imbricatum Blume, *Enum. Pl. Javae* 2: 220 (1828). E, I
Mecodium imbricatum (Blume) Copel., *Philipp. J. Sci.* 67: 22 (1938)
Type: INDONESIA (Java), *Blume s.n*., syntypes: L [0051723*], P [00623496*].
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10604*, BSIP!, TAIF [521295!], TNM!

Hymenophyllum javanicum Spreng., *Syst. Veg.,* ed. 16, 4(1): 132 (1827). E, S
Hymenophyllum crispum Nees & Blume, *Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur*. 11: 128, t.14, f.1 (1823), *non* Kunth, *Nov. Gen. Sp*. 1: 26 (1815); *Mecodium javanicum* (Spreng.) Copel., *Philipp. J. Sci*. 67: 20 (1938)
Type: INDONESIA (Java), *s.c. s.n*., lectotype: *Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur*. 11:128, t. 14, f. 1. (1823), designated by Field (2020).
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05685*, BSIP!, TAIF [473060!], TNM!

Hymenophyllum lobbii T.Moore ex Bosch, *Ned. Kruidk. Arch*. 5(3): 176 (1863). E, H
Meringium lobbii (T.Moore ex Bosch) Copel., *Philipp. J. Sci*. 67: 43 (1938)
Type: MALAYSIA (Borneo), *Lobb s.n.*, lectotype: K [000408702], designated by Croxall (1975); isolectotype: K [000408701].
Voucher: Kolombangara, 19 Jul 1990, *Glenny 2332*, WELT [P017454/A!].

Hymenophyllum pallidum (Blume) Ebihara & K.Iwats., *Blumea* 51(2): 232 (2006). E, S
Trichomanes pallidum Blume, *Enum. Pl. Javae* 2: 225 (1828); *Pleuromanes pallidum* (Blume) C.Presl, *Epimel. Bot*. 258 (1851 [‘1849’]); *Craspedoneuron pallidum* (Blume) Bosch, *Hymenophyll. Javan.* 14, t.8 (1861); *Crepidomanes pallidum* (Blume) K.Iwats., *Acta Phytotax. Geobot*. 35(4-6): 174 (1984)
Type: INDONESIA (Java), *Blume s.n*., holotype: L [0052385*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW06937*, BSIP!, TAIF [482799!], TNM!

Hymenophyllum serrulatum (C.Presl) C.Chr., *Index Filic*. 367 (1905). E, N
Didymoglossum serrulatum C.Presl, *Hymenophyllaceae* 23, 48 (1843); *Leptocionium serrulatum* (C.Presl) Bosch, *Ned. Kruidk. Arch*. 4(4): 383 (1859)
Type: PHILIPPINES, *Cuming 221*, lectotype: PRC, designated by Iwatsuki & Ebihara (2022); isolectotypes: B [20 0102854*], BM [001044782*] [001044786*], E

[00413875*], GOET [008794*], LE [00007987*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11670*, BSIP!, TAIF [498910!], TNM!

VANDENBOSCHIA Copel., *Philipp. J. Sci.* 67: 51 (1938)
Vandenboschia maxima (Blume) Copel., *Philipp. J. Sci.* 67: 54 (1938). R, R
Trichomanes maximum Blume, *Enum. Pl. Javae* 2: 228 (1828); *Lacosteopsis maxima* (Blume) Nakaike, *Enum. Pterid. Jap., Filic.* 22 (1975); *Crepidomanes maximum* (Blume) K.Iwats., *J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot.* 13(5): 531 (1985)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L [0544661*], designated by Nakaike (1982); isolectotypes: L [0544662*] [0544663*], K [000361865*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, Chen et al. SITW06951, BSIP!, TNM!

DIPTERIDACEAE Seward & E.Dale, *Philos. Trans.,* ser. B, 194: 487, 499, 502 (1901)
DIPTERIS Reinw., *Syll. Pl. Nov.* 2: 3 (1825)
Dipteris conjugata Reinw., *Syll. Pl. Nov.* 2: 3 (1825). T, S
Type: INDONESIA (Maluku), *Reinwardt s.n.*, lectotype: L [0051580*], designated by Field (2020).
Voucher: Guadalcanal, 400–1000 m, 30 Jun 2014, *Chen et al. SITW05250*, BSIP!, TAIF [464732!], TNM!

GLEICHENIACEAE C.Presl, *Reliq. Haenk.* 1: 70 (1825)
DICRANOPTERIS Bernh., *Neues J. Bot.* 1(2): 38–39 (1805)
Dicranopteris linearis (Burm.f.) Underw. var. ***linearis***, *Bull. Torrey Bot. Club* 34: 250 (1907). C, T
Polypodium lineare Burm.f., *Fl. Indica* 235 (1768)
Type: INDONESIA (Java), *van Santen s.n.*, holotype: G-PREL [00360111*].
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05386*, BSIP!, TAIF [471889!], TNM!
Note: Wei et al. (2021) showed the presence of cryptic species in *D. linearis* and elevated several Asian varieties to species level. Here we follow the conventional classification, but further study is needed to clarify the relationship among the varieties.

Dicranopteris linearis (Burm.f.) Underw. var. ***altissima*** Holttum, *Reinwardtia* 4: 276 (1957). C, H
Type: MALAYSIA (Peninsular Malaysia, Johore), *Corner SFN 31447*, lectotype: SING!, designated by Holttum (1959a); isolectotypes: K [000398008*], L.
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05401*, BSIP!, TAIF [471821!], TNM!

Dicranopteris linearis (Burm.f.) Underw. var. ***montana*** Holttum, *Reinwardtia* 4: 276 (1957). C, P
Type: MALAYSIA (Peninsular Malaysia, Perak), *Molesworth Allen 2720*, holotype: SING.
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10463*, BSIP!, TAIF [519977!], TNM!

DIPLOPTERYGIUM (Diels) Nakai, *Bull. Natl. Sci. Mus. Tokyo* 29: 47 (1950)

Diplopterygium clemensiae (Copel.) Parris, *Bull. Natl. Mus. Nat. Sci., Tokyo, B*. 38(3): 119 (2012). C, B
Hicriopteris clemensiae Copel., *Univ. Calif. Publ. Bot.* 18: 217 (1942)
Type: PAPUA NEW GUINEA, *Clemens 41227*, holotype: MICH [1190606*]; isotypes: UC [662805*], US [00048847*].
Voucher: Guadalcanal, 2286 m [7500 ft], 9 Nov 1962, *Dennis BSIP 518*, BSIP!, L [3545097*], US [01421178*].
Note: The photographs erroneously labelled as this species in Chen et al. (2017a) actually depict *D. sordidum* (Copel.) Parris. *Diplopterygium clemensiae* differs from *D. sordidum* by having dark ovate to lanceolate scales along the rachises and costae (vs. brown linear scales). This species is recorded only near the summit of Mt. Popomanaseu in the Solomon Islands.

Diplopterygium longissimum (Blume) Nakai, *Bull. Natl. Sci. Mus., Tokyo* 29: 53 (1950). C, O
Gleichenia longissima Blume, *Enum. Pl. Javae* 2: 250 (1828)
Type: INDONESIA (Java), *Blume s.n.*, holotype: L.
Voucher: Santa Isabel, 600–1000 m, 6 Jul 2014, *Chen et al. SITW05665*, BSIP!, TAIF [473048!] [473049!], TNM!

Diplopterygium sordidum (Copel.) Parris, *Malayan Nat. J.* 50(4): 252 (1997). C, E
Gleichenia sordida Copel., *Leafl. Philipp. Bot.* 3: 798 (1910); *Hicriopteris sordida* (Copel.) Copel., *Fern Fl. Philipp*. 1: 44 (1958)
Type: PHILIPPINES (Mindanao), *Elmer 11423a*, lectotype: MICH [1190539*], designated by Holttum (1959); isolectotypes: BM [001038235*], L [0397365*], US [00134657*].
Voucher: Makira, 910 m, 1 Jul 2015, Chen et al. *SITW06877*, BSIP!, TAIF [482825!], TNM!
Note: The photographs erroneously labelled as *D. clemensiae* in Chen et al. (2017a) depict *D. sordidum*.

GLEICHENIA Sm., *Mém. Acad. Roy. Sci. (Turin)* 5: 419 (1793), *nom. cons.*
Gleichenia vulcanica Blume, *Enum. Pl. Javae* 2: 251 (1828). T, E
Calymella vulcanica (Blume) C.Presl, *Abh. Königl. Böhm. Ges. Wiss.*, ser. 5, 5: 338 (1848)
Type: INDONESIA (Java), *Blume s.n.*, holotype: L.
Voucher: Guadalcanal, 2133 m [7000 ft], 27 Oct 1965, *Braithwaite BSIP 4651*, BSIP!, L [3556182*].

STICHERUS C.Presl, *Tent. Pterid*. 51 (1836)
Sticherus brassii (C.Chr.) Copel., *Philipp. J. Sci*. 76: 357 (1941). C, B
Gleichenia brassii C.Chr., *Brittonia* 2: 271 (1937)
Type: PAPUA NEW GUINEA, *Brass 4922*, holotype: BM [001038261*]; isotypes: BM [001038262*], BO, BRI [AQ0024701*], GH [00021227*], NY [00127579*].
Voucher: Guadalcanal, 2133 m [7000 ft], 29 Oct 1965, *Braithwaite BSIP 4680*, L [3545117*].
Note: Christensen (1937) stated that "Type material of the new species is to be found with few exceptions in my herbarium" (now in BM), and we regard this as designation

of holotypes. There are two sheets of *Brass 4922* in BM, and we consider the one from Christensen's herbarium as the holotype.

Sticherus hirtus (Blume) Ching var. ***amboinensis*** (Alderw.) C.W.Chen, *comb. nov.* C, E
Gleichenia amboinensis Alderw., *Bull. Dépt. Agric. Indes Néerl.* 18: 3 (1908); *Gleichenia hirta* Blume var. *amboinensis* (Alderw.) Holttum, *Reinwardtia* 4: 269 (1957)
Type: INDONESIA (Maluku, Ambon), *Teysmann s.n.*, holotype: BO; isotype: L [3534838*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11646*, BSIP!, TNM!
Note: Differs from var. *candidus* by having scales throughout the abaxial surface of the costules (Holttum, 1959a). The photographs shown in Chen et al. (2017a) under *S. hirtus* are a mixture of two varieties; only the photograph of *Chen et al. SITW11646* is var. *amboineensis*.

Sticherus hirtus (Blume) Ching var. ***candidus*** (Rosenst.) Nakai, *Bull. Natl. Sci. Mus. (Tokyo)* 29: 19 (1950). C, E
Gleichenia candida Rosenst., *Repert. Spec. Nov. Regni Veg.* 5: 33 (1908); *Gleichenia hirta* Blume var. *candida* (Rosenst.) Holttum, *Reinwardtia* 4: 269 (1957)
Type: PAPUA NEW GUINEA, *Werner 72 = Filices novoguineenses exsicc. 44*, lectotype: B [20 0097768*], designated by Holttum (1959a); isolectotypes: BM [001038259*], S-P [4198*], UC [391821*], US [00134636*].
Voucher: Vanikoro, 420–780 m, 18 Jun 2016, *Chen et al. SITW11008*, BSIP!, TAIF [498886!] [498887!], TNM!
Note: Differs from var. *amboinensis* by having nearly glabrous costules (Holttum, 1959). The photographs shown in Chen et al. (2017a) under *S. hirtus* are of var. *candidus*, except for *Chen et al. SITW11646*, which is var. *amboinensis*.

Sticherus milnei (Baker) Ching, *Sunyatsenia* 5: 284 (1940). C, N
Gleichenia milnei Baker, *Syn. Fil.* 449 (1868)
Type: VANUATU, *Milne s.n.*, lectotype: K [001057806*], designated by Holttum (1959a).
Voucher: San Jorge, 20–50 m, 3 Jun 2016, *Chen et al. SITW10462*, BSIP!, TAIF [519943!], TNM!
Note: *Gleichenia kajewskii* Copel., described from Guadalcanal, is a synonym of this species.

Sticherus oceanicus (Kuhn) Ching, *Sunyatsenia* 6: 284 (1940). C, I
Gleichenia oceanica Kuhn, *Verh. Zool.-Bot. Ges. Wien* 19: 583 (1869)
Type: VANUATU, *Herus 66*, lectotype: B [20 0097746*], designated by Holttum (1959a, first-step) and here by Chen (second-step); isotypes: B [20 0097745*], P [01300008*] [01300009*] [01300010*] [01300011*] [01300012*] [01300013*] [01300015*], S-P [4178*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07538*, BSIP!, TNM!
Note: There are two sheets of *Herus 66* in B, and we selected the one with Kuhn's annotation as lectotype.

LYGODIACEAE M.Roem., *Handb. allg. Bot.* 3: 520 (1840)

LYGODIUM Sw., *J. Bot. (Schrader)* 1800(2): 7, 106 (1801)
Lygodium circinnatum (Burm.f.) Sw., *Syn. Fil.* 153 (1806). C, S
Ophioglossum circinnatum Burm.f., *Fl. Indica* 228 (1768)
Type: INDONESIA (Java), *Pryon s.n.*, lectotype: G-PREL [00818001], designated by Holttum (1959b).
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10470*, BSIP!, TAIF [519901!] [519902!] [519903!], TNM!

Lygodium microphyllum (Cav.) R.Br., *Prodr.* 162 (1810). C, T
Ugena microphylla Cav., *Icon.* 6(2): 76, t. 595, f. 2 (1801)
Type: PHILIPPINES (Luzon), *Nee s.n.*, lectotype: MA [476456] [476456-2], designated by Holttum (1959b).
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10469*, BSIP!, TAIF [519958!], TNM!

Lygodium reticulatum Schkuhr, *24. Kl. Linn. Pfl.-Syst.* 1: 139, t.139 (1809). C, G
Type: FRENCH POLYNESIA (Tahiti), *Forster s.n.*, holotype: B-W [19478010*].
Voucher: Vanikoro, 20–250 m, 20 Jun 2016, *Chen et al. SITW11042*, BSIP!, TAIF [498860!] [498861!] [498862!], TNM!

Lygodium trifurcatum Baker, *Syn. Fil.* 437 (1868). C, D
Type: SOLOMON ISLANDS (Makira), *Milne 511*, lectotype: K [001057825*], designated by Holttum (1959, first-step) and here by Chen (second-step); isolectotype: K [001057824*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10471*, BSIP!, TAIF [519962!], TNM!
Note: Holttum (1959b) designated the specimens in K as the type, but there are two duplicates; therefore we make a second lectotypification.

Lygodium versteegii Christ, *Nova Guinea* 8: 161 (1909). C, E
Type: INDONESIA (Indonesian New Guinea), *Versteeg 1400*, lectotype: P [01262429*], designated here by Chen; isolectotypes: BO, G, U [0007517*].
Voucher: Choiseul, 28 Feb 1964, *Whitmore BSIP 3971*, BSIP!
Note: We selected the syntype in P with Christ's annotation as lectotype.

SCHIZAEACEAE Kaulf., *Wesen Farrenkr.* 119 (1827)
ACTINOSTACHYS Wall., *Numer. List* [no. 1] (1829)
Actinostachys digitata (L.) Wall., *Numer. List* [no. 1] (1829). T, T
Type: SRI LANKA, *Hermann s.n.*, lectotype: BM [000621756*], designated by Holttum (1959b).
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07592*, BSIP!, TAIF [486591!], TNM!

Actinostachys wagneri (Selling) C.F.Reed, *Bol. Soc. Brot.*, sér. 2, 21: 131 (1948). T, H
Schizaea wagneri Selling, *Svensk. Bot. Tidskr.* 40: 278 (1946)
Type: PAPUA NEW GUINEA (Admiralty Is.), *Grether & Wagner 4177*, holotype: UC [701236*]; isotypes: BISH [1000504*], GH [00022029*], K [000408661*], MICH [1191433*], US [00134444*].

Voucher: Nggatokae, 50–850 m, 9 Oct 2013, *Chen et al. SITW04884*, BSIP!, TAIF [463416!], TNM!

SCHIZAEA Sm., *Mém. Acad. Roy. Sci. (Turin)* 5: 419, pl. 9, f. 9 (1793)
Schizaea dichotoma (L.) Sm., *Mém. Acad. Roy. Sci. (Turin)* 5: 422, t. 9, f. 9 (1793). T, S
Acrostichum dichotomum L., *Sp. Pl.* 2: 1068 (1753)
Type: VIETNAM [Cochinchina], lectotype: Petiver, *Gazophyl. Nat.* t. 70, f. 12 (1709), designated by Holttum (1959b).
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10597*, BSIP!, TAIF [521290!], TNM!
Note: Three taxa recognised in Chen et al. (2017a) are all tentatively included here. Upon examination of the lectotype of *S. dichotoma*, we found that it is more similar to the plants recognised as *S. biroi* Richter in Chen et al. (2017a). However, *S. dichotoma* as currently circumscribed is polymorphic and likely includes more than one species (Kuo et al., unpubl.).

Schizaea malaccana Baker, *Syn. Fil.* 428 (1868). T, H
Type: MALAYSIA (Peninsular Malaysia, Mt. Ophir), *Cuming 379*, lectotype: K [000377402*], designated by Field (2020); isolectotypes: BM [000711561] [000711562].
Voucher: Guadalcanal, 1676 m [5500 ft], 9 Nov 1962, *Dennis BSIP 522*, BSIP!

PLAGIOGYRIACEAE Bower, *Ann. Bot. (Oxford)* 40: 484 (1926)
PLAGIOGYRIA (Kunze) Mett., *Abh. Senckenberg. Naturf. Ges.* 2(2): 265 (1858)
Plagiogyria egenolfioides (Baker) Copel. var. ***decrescens*** (C.Chr.) X.C.Zhang & Noot., *Blumea* 42: 483 (1997). T, E
Plagiogyria tuberculata var. *decrescens* C.Chr., *Brittonia* 2: 284 (1937)
Type: PAPUA NEW GUINEA, *Brass 4746*, holotype: BM [001044007*]; isotypes: BRI-AQ [0024856*], GH [00021777*], NY [00127439*].
Voucher: Guadalcanal, 2133 m [7000 ft], 29 Oct 1965, *Braithwaite RSS 4684*, BSIP, L [1257992*].

Plagiogyria glauca (Blume) Mett., *Abh. Senckenberg. Naturf. Ges.* 2(2): 273 (1858). T, P
Lomaria glauca Blume, *Enum. Pl. Javae* 2: 204 (1828)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L [0051951*], designated by Zhang & Nooteboom (1998).
Voucher: Guadalcanal, 1828 m [6000 ft], 31 Oct 1965, *Braithwaite RSS 4730*, BSIP!, LAE*

DICKSONIACEAE M.R.Schomb., *Reis. Br.-Guiana* 3: 1047 (1849)
CALOCHLAENA (Maxon) M.D.Turner & R.A.White, *Amer. Fern J.* 78(3): 91 (1988)
Calochlaena straminea (Labill.) M.D.Turner & R.A.White, *Amer. Fern J.* 78(3): 92 (1988). T, N
Dicksonia straminea Labill., *Sert. Austro-Caledon.* 7, t. 10 (1824); *Sitobolium stramineum* (Labill.) *Brack., U.S. Expl. Exped., Filic.* 16 (1854); *Dennstaedtia straminea* (Labill.) J.Sm., *Hist. Fil.* 265 (1875); *Culcita straminea* (Labill.) Maxon, *J. Wash. Acad. Sci.* 12: 457 (1922)

Type: NEW CALEDONIA, *Labillardiere s.n.*, lectotype: P [00642564*], designated by Brownlie (1977); isolectotypes: BR [0000006978877*], FI [011565*], K [001090372*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07570*, BSIP!, TAIF [486607!], TNM!, VT!

DICKSONIA l'Hér., *Sert. angl.* 30 (1789)
Dicksonia brackenridgei Mett., *Ann. Sci. Nat., Bot.*, sér. 4, 15: 81 (1861). TF, D
Dicksonia berteroana Brack., *U.S. Expl. Exped., Filic.* 16: 277 (1854), *non* Hook., *Sp. Fil.* 1: 67, t.23A (1844)
Type: FIJI, *Wilkes Explor. Exped. 3*, lectotype: US [00134817*], designated here by Lehnert; isolectotype: US [00067490*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07574*, BSIP!, TAIF [486603!], TNM!, VT!
Note: There are two sheets of *Wilkes Explor. Exped. 3* in US, and we selected the one with fertile pinnae as lectotype. A variable species as currently circumscribed (Noben & Lehnert 2013), and the Solomon population stands out by having mostly soft woolly hair.

Dicksonia sciurus C.Chr., *Brittonia* 2: 283 (1937). TF, B
Type: PAPUA NEW GUINEA, *Brass 4991*, holotype: BM [000097861*] [000097862*]; isotypes: BRI-AQ [0156340*], MICH [1190340*], NY [00127913*], UC [655480*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11624*, BSIP!, TAIF [498919!], TNM!
Note: Christensen (1937) stated that "Type material of the new species is to be found with few exceptions in my herbarium" (now in BM), and we regard this as designation of a holotype. There are two sheets of *Brass 4991* in BM, both from Christensen's herbarium, and these are clearly labelled as being part of a single specimen, in accordance with ICN Art. 8.3 (Turland et al., 2018).

CYATHEACEAE Kaulf., *Wesen Farrenkr.* 119 (1827)
ALSOPHILA R.Br., *Prodr.* 158 (1810)
Alsophila alta (Copel.) R.M.Tryon, *Contr. Gray Herb.* 200: 36 (1970). TF, D
Cyathea alta Copel., *Philipp. J. Sci.* 60: 104, t.10 (1936)
Type: SOLOMON ISLANDS (Santa Isabel), *Brass 3330*, holotype: PNH, destroyed; lectotype: MICH [1003409A*] [1003409B*], designated here by Lehnert; isolectotypes: BISH [1000446*] [1000447*], BO?, BRI-AQ [0145941*], GH [00020792*], L [0051232*].
Voucher: Kolombangara, 300–600 m, 17 Oct 2013, *Chen et al. SITW04976*, BSIP!, TAIF [464225!] [464226!] [464227!], TNM!
Note: The sheets designated as lectotype are clearly labelled as being part of a single specimen, in accordance with ICN Art. 8.3 (Turland et al., 2018).

Alsophila archboldii (C.Chr.) R.M.Tryon, *Contr. Gray Herb.* 200: 32 (1970). TF, B
Cyathea archboldii C.Chr., *Brittonia* 2: 278 (1937)
Type: PAPUA NEW GUINEA, *Brass 4551*, holotype: BM [001039973!]; isotypes: BRI-AQ [0024660*], GH [00020796*], MICH [1191149*], NY [00127852*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07547*, BSIP!, TAIF [487346!], TNM!, VT!

Alsophila rigens (Rosenst.) R.M.Tryon, *Contr. Gray Herb.* 200: 36 (1970). TF, B
Cyathea rigens Rosenst., *Repert. Spec. Nov. Regni Veg.* 12: 163 (1913)
Type: PAPUA NEW GUINEA, *Keysser B 79*, lectotype: S-P [3435*], designated by Holttum (1963); isolectotypes: B [20 0133019!], MICH [1191247*], UC [391974*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07576*, BSIP!, TAIF [486601!], TNM!, VT!

Alsophila solomonensis (Holttum) R.M.Tryon, *Contr. Gray Herb.* 200: 37 (1970). TF, B
Cyathea solomonensis Holttum, *Blumea* 12(2): 252 (1964)
Type: SOLOMON ISLANDS (Guadalcanal), *Whitmore & Womersley BSIP 1035*, holotype: LAE; isotypes: BSIP!, K [000647226!] [000647227*], L [0051405*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11595*, BSIP!, TAIF [498933!] [498934!], TNM!

CYATHEA Sm., *Mem. Acad. Roy. Sci. (Turin)* 5: 416 (1793)
Cyathea decurrens (Hook.) Copel., *Univ. Calif. Publ. Bot.* 14: 356 (1929). TF, F
Alsophila decurrens Hook., *Sp. Fil.* 1: 51 (1844)
Type: FIJI, *Nightingale s.n.*, lectotype: K [000638100!], designated here by Lehnert; isolectotype: K [000638099*].
Voucher: Vanikoro, 600 m, 27 Jul 2016, *Chen et al. SITW11083*, BSIP!, TAIF [498977!] [498978!] [498979!], TNM!
Note: *Nightingale s.n.* in K comprises two sheets, and these are not clearly labelled as being part of a single specimen. We selected as lectotype the one bearing the same "South-Sea Islands" locality as the protologue.

GYMNOSPHAERA Blume, *Enum. Pl. Javae* 2: 242 (1828)
Gymnosphaera hornei (Baker) Copel., *Ann. Cryptog. Phytopathol.* 5: 99 [*Gen. Fil.*] (1947). TF, D
Alsophila hornei Baker, *J. Bot.* 17: 293 (1879); *Cyathea hornei* (Baker) Copel., *Bull. Bernice P. Bishop Mus.* 59: 38 (1929)
Type: FIJI, *Horne 620*, holotype: K [000647526!] [000647527!].
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05626*, BSIP!, TAIF [472971!], TNM!
Note: *Horne 620* in K comprises two sheets with complementary material that together display all characters mentioned in the original description; they are clearly labelled as being part of a single specimen in accordance with ICN Art. 8.3 (Turland et al., 2018), and so are considered the holotype. They are the only known specimens of the type collection. Chen et al. (2017a) adopted a broadly circumscribed *Alsophila* which includes *Gymnosphaera*, but here we follow Dong & Zou (2018) who proposed recognition of *Gymnosphaera* as a distinct genus.

SPHAEROPTERIS Bernh., *J. Bot. (Schrader)* 1800(2): 122 (1801)
Sphaeropteris aciculosa (Copel.) R.M.Tryon, *Contr. Gray Herb.* 200: 21 (1970). TF, B
Cyathea aciculosa Copel., *Philipp. J. Sci.* 60: 104, t.9 (1936)
Type: SOLOMON ISLANDS (Makira), *Brass 2887*, lectotypes: MICH [1051140A*] [1051140B*] [1051140C*], designated by Holttum (1963); isolectotypes: BISH [1000247*], BRI-AQ [0024664*], GH [00020790*] [00020791*], L [0051225*].

Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05369*, BSIP!, TAIF [471896!], TNM!

Sphaeropteris brackenridgei (Mett.) R.M.Tryon, *Contr. Gray Herb*. 200: 24 (1970). TF, B
Cyathea brackenridgei Mett., *Ann. Mus. Bot. Lugduno-Batavi* 1: 56 (1863)
Type: SOLOMON ISLANDS, *Wilkes Explor. Exped. s.n.*, holotype: B fide Holttum (1963), not found.
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10461*, BSIP!, TAIF [498623!] [498624!] [498625!] [519954!] [519955!], TNM!

Sphaeropteris felina (Roxb.) Pic.Serm., *Webbia* 45(2): 351 (1991). TF, H
Polypodium felinum Roxb., *Calcutta J. Nat. Hist*. 4: 495 (1844); *Cyathea felina* (Roxb.) C.V.Morton, *Contr. U.S. Natl. Herb*. 38(7): 344 (1974)
Type: INDONESIA (Maluku, Ambon), *Smith s.n.*, lectotype: G [00348335*], designated by Morton (1974); isotypes: BR [0000006869489*], LINN-HS [1625.74*] [1625.75*].
Voucher: Kolombangara, 0 m, 7 Sep 1965, *Braithwaite RSS 4493*, L [1259975*] [1259976*].

Sphaeropteris lunulata (G.Forst.) R.M.Tryon, *Contr. Gray Herb*. 200: 22 (1970). TF, I
Polypodium lunulatum G.Forst., *Fl. Ins. Austr*. 83 (1786); *Alsophila lunulata* (G.Forst.) R.Br., *Prod.* 158 (1810); *Cyathea lunulata* (G.Forst.) Copel., *Bull. Bernice P. Bishop Mus*. 59: 37 (1929)
Type: FRENCH POLYNESIA, *Forster s.n.*, lectotype: GOET [012819!], designated by Holttum (1963); isolectotypes: B-W [19710-010!], BM [001048420!], MEL [295771*], PRC [455600*] [455601*].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10549*, BSIP!, TAIF [498583!] [498584!] [498585!] [520593!] [520594!], TNM!

Sphaeropteris moseleyi (Baker) R.M.Tryon, *Contr. Gray Herb*. 200: 22 (1970). TF, B
Cyathea moseleyi Baker, *J. Linn. Soc., Bot.* 16: 104 (1876)
Type: PAPUA NEW GUINEA (Admiralty Is.), *Moseley s.n.*, holotype: K [000824384!] [000824385*]; isotype: BM [001048074!].
Voucher: Vanikoro, 20–250 m, 20 Jun 2016, *Chen et al. SITW11041*, BSIP!, TAIF [498863!] [498864!] [498865!], TNM!
Note: Two sheets of *Moseley s.n.* in K are considered as holotype because they bear a single, original label in common which is in accordance with ICN Art. 8.3 (Turland et al., 2018). Newly recorded from the Solomon Islands.

Sphaeropteris samoensis (Brack.) R.M.Tryon, *Contr. Gray Herb*. 200: 24 (1970). TF, D
Alsophila samoensis Brack., *U.S. Expl. Exped., Filic*. 16: 287, t.40, f.1 (1854)
Type: SAMOA, *Wilkes Explor. Exped. 6*, holotype: US [00134837*].
Voucher: Santa Isabel, 22 Oct 1963, *Whitmore BSIP 2275*, L [1259565*] [1259569*].

Sphaeropteris truncata (Brack.) R.M.Tryon, *Contr. Gray Herb*. 200: 25 (1970). TF, D
Alsophila truncata Brack., *U.S. Expl. Exped., Filic*. 16: 289, t.41 (1854); *Hemitelia truncata* (Brack.) Christ, *Ann. Jard. Bot. Buitenzorg* 15(1): 81, t.13, f.4 (1898); *Cyathea truncata* (Brack.) Copel., *Philipp. J. Sci., C.* 4: 39 (1909)

Type: FIJI, *Wilkes Explor. Exped. s.n.*, lectotype: US [00134844*], designated by Holttum (1964); isolectotypes: GH [00020449*], K [000645243!], P.
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11628*, BSIP!, TAIF [498918!], TNM!

Sphaeropteris vittata (Copel.) R.M.Tryon, *Contr. Gray Herb*. 200: 25 (1970). TF, B
Cyathea vittata Copel., *Philipp. J. Sci*. 60: 102, t.7 (1936)
Type: SOLOMON ISLANDS (Santa Isabel), *Brass 3313*, lectotype: GH [00020922*] [00020923*], designated by Holttum (1963); isolectotypes: BISH [1000264*] [1000469*], BRI-AQ [0146462*], MICH [1003423A*] [1003423B*].
Voucher: Guadalcanal, 100–500 m, 27 Jul 2014, *Chen et al. SITW05725*, BSIP!, TAIF [472151!], TNM!
Note: *Cyathea barotu* Copel., described from Makira, is a synonym of this species.

SACCOLOMATACEAE Doweld, *Phytologia* 90(3): 417 (2008)
SACCOLOMA Kaulf., *Berlin. Jahrb. Pharm. Verbundenen Wiss*. 21: 51 (1820)
Saccoloma campylurum (Kunze) Mett. var. ***insulare*** (Hovenkamp & T.T.Luong) C.W.Chen, *Sol Amazing* 179 (2017). TF, D
Orthiopteris campylura (Kunze) Copel. var. *insularis* Hovenkamp & T.T.Luong, *PhytoKeys* 53: 52 (2015)
Type: SOLOMON ISLANDS (Makira), *Brass 2914*, holotype: L [0319881]; isotypes: K, MICH.
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10433*, BSIP!, TAIF [498639!] [498640!] [498641!] [498642!] [499342!] [519457!], TNM!

CYSTODIACEAE J.R.Croft, *Kew Bull*. 41(4): 797 (1986)
CYSTODIUM J.Sm., *Gen. Fil*. ad t. 96 (1841)
Cystodium sorbifolium (J.Sm.) J.Sm. subsp. ***solomonense*** J.R.Croft, *Kew Bull.* 41(4): 802 (1986). T, B
Type: SOLOMON ISLANDS (Santa Isabel), *Beer's collectors BSIP 7261*, holotype: LAE; isotypes: BSIP!, K.
Voucher: Malaita, 150–350 m, 22 Jul 2015, *Chen et al. SITW07685*, BSIP!, TAIF [486699!], TNM!, VT!

LINDSAEACEAE C.Presl ex M.R.Schomb., *Reis. Br.-Guiana* 3: 883 (1849)
LINDSAEA Dryand. ex Sm., *Mém. Acad. Roy. Sci. (Turin)* 5: 413, pl. 9, f. 4 (1793)
Lindsaea agatii (Brack.) Lehtonen & Tuomisto, *Bot. J. Linn. Soc*. 163(3): 339 (2010). T, K
Schizoloma agatii Brack., *U.S. Expl. Exped., Filic*. 216 (1854); *Lindsaea ensifolia* subsp. *agatii* (Brack.) K.U.Kramer, *Acta. Bot. Neerl*. 15: 570 (1967).
Type: FIJI, *U.S. Expl. Exped. s.n.*, lectotype: US [00134886*], designated by Brownlie (1977); isolectotypes: K [000721779*], P [00633682*].
Voucher: Vanikoro, 20–250 m, 20 Jun 2016, *Chen et al. SITW11039*, BSIP!, TAIF [498867!], TNM!

Lindsaea blanda Mett. ex Kuhn, *Linnaea* 36: 80 (1869). E, H
Lindsaea pulchella (J.Sm.) Mett. ex Kuhn var. *blanda* (Mett. ex Kuhn) K.U.Kramer, *Blumea* 15(2) (1968)

Type: INDONESIA (Java), *Wichura s.n.*, lectotype: B [20 0144992*], designated by Kramer & Tindale (1976, first-step) and Field (2020, second-step); isolectotype: B [20 0144993].
Voucher: Nggatokae, 50–850 m, 9 Oct 2013, *Chen et al. SITW04849*, BSIP!, TAIF [463378!], TNM!
Note: Kramer (1967a, 1970, 1971) recognised *L. blanda* as a variety of *L. pulchella*, but Lehtonen et al. (2010), informed by phylogenetic evidence, treated it as a species.

Lindsaea brevipes Copel., *Philipp. J. Sci., C.* 6: 83 (1911). T, I
Lindsaea lucida subsp. *brevipes* (Copel.) K.U.Kramer, *Blumea* 15: 567 (1968)
Type: PAPUA NEW GUINEA, *King 237*, holotype: MICH [1190700*]; isotype: BO.
Voucher: Kolombangara, 300–600 m, 17 Oct 2013, *Chen et al. SITW04953*, BSIP!, TAIF [463859!], TNM!

Lindsaea cheilosora (K.U.Kramer) Lehtonen, *comb. et stat. nov.* E, D
Lindsaea repens (Bory) Thwaites var. *cheilosora* K.U.Kramer, *Blumea* 18: 181 (1970)
Type: SOLOMON ISLANDS (San Jorge), *Braithwaite RSS 4541*, holotype: U [0007340*]; isotypes: K [000757735*] [000757736*].
Voucher: Vella Lavella, 312–775 m, 28 Oct 2013, *Chen et al. SITW04013*, BSIP!, TAIF [459822!], TNM!
Note: Kramer (1967a, 1970, 1971) treated *L. repens* (Bory) Thwaites in a broad sense, with 11 varieties. Many of these, and at least those in the Solomon Islands, can be readily distinguished based on the soral position, the shape of indusium bases, and by the depth and width of the pinnule incisions. Only a few of the varieties have been sampled for molecular phylogenies, but they do not form a clade; it has been suggested that they should be recognised at species rank (Lehtonen et al., 2010). Here we follow this classification despite the fact that, in the Solomon Islands, only *L. sessilis* was sampled for the molecular phylogeny. This requires three new combinations, all provided herein (*L. delicatula* and *L. marquesensis* are the other two).

Lindsaea chrysolepis K.U.Kramer, *Blumea* 18: 187, f.15 (1970). E, D
Type: SOLOMON ISLANDS (Guadalcanal), *Braithwaite RSS 4052*, holotype: U [0007332*]; isotypes: BSIP!, K [000784588*] [000784589*].
Voucher: Nggatokae, 50–850 m, 9 Oct 2013, *Chen et al. SITW04848*, BSIP!, TAIF [463377!], TNM!

Lindsaea cultrata (Willd.) Sw., *Syn. Fil.* 119 (1806). T, R
Adiantum cultratum Willd., *Phytographia* 14, t.10, f.2 (1794)
Type: INDIA (Malabaria), *Klein s.n.*, holotype: B-W [20052010*].
Voucher: Makira, 22 Sep 1932, *Brass 2900*, A*, BISH [1147887!], BRI, MICH, P [01362796!].

Lindsaea delicatula Christ, *Verh. Nat. Ges. Basel* 11: 258, t. 3, f.1-3 (1896). E, E
Davallia delicatula Christ, *Verh. Nat. Ges. Basel* 11: 224, t. 3, f.1-3 (1896)
Type: INDONESIA (Sulawesi), *Sarasin 937*, lectotype: P [00633736!], designated by Kramer (1967a); isolectotype: BAS!
Voucher: Makira, 1 Aug 1965, *Braithwaite RSS 4257*, K, U [231553!].
Note: Christ (1896) cited a gathering that consisted of at least two duplicates, one in P

and one in BAS. Christ himself was based in Basel and donated the material of his work to BAS (Jurriaan M. de Vos, pers. comm.). Kramer (1967a) cited the specimen in P as type and thus effectively designated a lectotype. When publishing the name *Davallia delicatula*, Christ (1896) referred to the illustration of the new taxon as *Lindsaea delicatula* n. sp. (as "*Lindsaya*"). According to ICN Art. 36.3, these two names are alternative names that were published before 1953, and therefore are both valid. Only a single collection is known from the Solomon Islands. Kramer (1970) considered it to represent a juvenile form of a probably undescribed species. We identified it as *L. delicatula*.

Lindsaea ensifolia Sw., *J. Bot. (Schrader)* 1800(2): 77 (1801). T, T
Type: MAURITIUS, *s.c., s.n.*, holotype: S-P [5538*].
Voucher: Guadalcanal, 400–1000 m, 30 Jun 2014, *Chen et al. SITW05235*, BSIP!, TAIF [480899!], TNM!

Lindsaea gueriniana (Gaudich.) Desv., *Mem. Soc. Linn. Paris* 6, 2: 312 (1827). T, R
Schizoloma guerinianum Gaudich., *Ann. Sci. Nat. (Paris)* 3: 508 (1824); *Isoloma guerinianum* (Gaudich.) Fée, *Mém. Foug. 5*: 108 [*Gen. Filic.*] (1852)
Type: INDONESIA (Maluku), *Gaudichaud s.n.*, holotype: P [00633761*]; isotypes: B [20 0144788*] [20 0144789*], G, K, L [0051813*], P [00633760*].
Voucher: San Jorge, 20–450 m, 6 Jun 2016, *Chen et al. SITW10506*, BSIP!, TAIF [498609!] [519883!] [519884!], TNM!

Lindsaea harveyi Carruth., *Fl. Vit.* 338 (1873). T, D
Type: FIJI, *Harvey s.n.*, lectotype: K [000757192*], designated by Kramer (1967a); isolectotype: BM [001044369*].
Voucher: Guadalcanal, 1706 m [5600 ft], 2 Nov 1965, *Braithwaite RSS 4753*, BSIP!, U.

Lindsaea jarrettiana K.U.Kramer, *Blumea* 18: 188, f.10 (1970). E, A
Type: SOLOMON ISLANDS (Guadalcanal, Mt. Popomanaseu), *Braithwaite RSS 4083*, holotype: U [0007336*]; isotype: K [000784593*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11666*, BSIP!, TNM!
Note: Endemic.

Lindsaea kingii Copel., *Philipp. J. Sci., C.* 6: 83 (1911). T, I
Type: PAPUA NEW GUINEA, *King 241*, holotype: MICH [1190712*]; isotype: BM.
Voucher: Vanikoro, 100–370 m, 24 Jun 2016, *Chen et al. SITW11076*, BSIP!, TAIF [498984!], TNM!

Lindsaea lapeyrousei (Hook.) Baker, *Syn. Fil.* 106 (1868). T, D
Davallia lapeyrousei Hook., *Sec. Cent. Ferns*, t. 56 (1861)
Type: SOLOMON ISLANDS (Vanikoro), *Moore s.n.*, lectotype: K [000784086*], designated by Kramer (1970).
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10602*, BSIP!, TAIF [498897!] [521292!], TNM!
Note: The species epithet honours the La Pérouse expedition and should therefore be spelled as *lapeyrousei*, not *lapeyrousii* as in Chen et al. (2017a).

Lindsaea marquesensis (E.D.Br.) Lehtonen, *comb. et stat. nov*. E, G
Lindsaea repens (Bory) Thwaites var. *marquesensis* E.D.Br., *Bull. Bernice P. Bishop Mus*. 89: 51, t. 9 (1931)
Type: FRENCH POLYNESIA (Marquesas), *Brown 1083*, holotype: BISH [1000355*].
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10605*, BSIP!, TAIF [498896!] [521296!], TNM!
Note: This species was given as *Lindsaea* sp. in Chen et al. (2017a: 204–205).

Lindsaea microstegia Copel., *Philipp. J. Sci., C.* 6: 83 (1911). E, E
Type: PAPUA NEW GUINEA, *King 242*, holotype: MICH [1190599*].
Voucher: Vella Lavella, 312–775 m, 28 Oct 2013, *Chen et al. SITW03954*, BSIP!, TAIF [459707!], TNM!

Lindsaea obtusa J.Sm. ex Hook., *Sp. Fil*. 1: 224 (1846). T, S
Type: MALAYSIA (Peninsular Malaysia, Malacca), *Cuming 394*, lectotype: K [000115053*], designated by Kramer & Tindale (1976); isolectotypes: B [20 0144830*], E [00413942*], GH [0021526*], P [00633684*] [00633685*].
Voucher: Vanikoro, 100–370 m, 24 Jun 2016, *Chen et al. SITW11077*, BSIP!, TAIF [498983!], TNM!

Lindsaea pacifica K.U.Kramer, *Blumea* 18: 173, f.5 (1970). T, D
Lindsaea seemannii Carruth., *Fl. Vit*. 338 (1873), *non* J.Sm., *Bot. Voy. Herald* 6: 239 (1854)
Type: FIJI, *Seemann 764*, lectotype: K [000755444*], designated by Kramer (1970); isolectotypes: B [20 0145004*], BM, P [00633758*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11578*, BSIP!, TNM!

Lindsaea pulchra (Brack.) Carruth., *Fl. Vit*. 337 (1873). E, D
Synaphlebium pulchrum Brack., *U.S. Expl. Exped., Filic*. 16: 223 (1854)
Type: FIJI, *U.S. Expl. Exped. 2*, lectotype: US [00134908*], designated by Kramer (1970); isolectotypes: K [000784586*], P [00633511*].
Voucher: Vanikoro, 420–780 m, 18 Jun 2016, *Chen et al. SITW11011*, BSIP!, TAIF [498883!] [498884!] [498885!], TNM!
Note: This species was misidentified as *L. vitiensis* K.U.Kramer in Chen et al. (2017a). Morphologically, *L. pulchra* can be distinguished from *L. vitiensis* by having reticulate venation.

Lindsaea rigida J.Sm. ex Hook., *Sp. Fil*. 1: 217, t. 63 A (1846). E, I
Lindsaenium rigidum (J.Sm.) Fée, *Mém. Foug.* 5: 333, pl. 27 bis [*Gen. Filic.*] (1852)
Type: MALAYSIA (Peninsular Malaysia, Malacca), *Lobb s.n.*, lectotype: K [000115362*], designated by Kramer (1971); isolectotypes: E [00417541*], K [000115363*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW 07543*, BSIP!, TAIF [487350!], TNM!, VT!
Note: Kramer (1970) doubtfully identified *Braithwaite 4756* (U!) as juvenile, yet fertile, *L. rigida*. The specimen indeed is fertile, but there are very few spores and they are all more or less collapsed. It resembles *L. rigida* by having sori mostly at the distal margin of the pinnules, but the indusia, laminar texture and rhizome scales are all different. In

our opinion the specimen is not *L. rigida*, but we are unable to identify it. It may be a hybrid.

Lindsaea salomonis K.U.Kramer, *Blumea* 18: 186, f.16 (1970). E, A
Type: SOLOMON ISLANDS (Guadalcanal, Mt. Popomanaseu), *Braithwaite RSS 4675*, holotype: U [0007345*]; isotypes: BSIP!, K [000784587*], P [01349700*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW 06938*, BSIP!, TAIF [482800!], TNM!
Note: Endemic.

Lindsaea sessilis Copel., *Philipp. J. Sci., C.* 6: 82 (1911). E, I
Lindsaea repens (Bory) Thwaites var. *sessilis* (Copel.) K.U.Kramer, *Blumea* 15: 568 (1968)
Type: PAPUA NEW GUINEA, *King 244*, holotype: MICH [1190589*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10423*, BSIP!, TAIF [519423!], TNM!

Lindsaea tetragona K.U.Kramer, *Blumea* 15: 564 (1968). T, N
Type: INDONESIA (Maluku, Ambon), *Binnendijk 160*, holotype: U [0007350*].
Voucher: Kolombangara, 230–330 m, 19 Oct 2012, *Chen et al. SITW01125*, BSIP!, TAIF [421464!], TNM!

ODONTOSORIA (C.Presl) Fée, *Mém. Foug.* 5: 325 [*Gen. Filic.*] (1852)
Odontosoria chinensis (L.) J.Sm., *Bot. Voy. Herald* 10: 430 (1857). R, S
Trichomanes chinense L., *Sp. Pl.* 2: 1099 (1753); *Adiantum chinense* (L.) Burm.f., *Fl. Indica* 236 (1768); *Davallia chinensis* (L.) J.Sm., *Mém, Acad. Roy. Sci. (Turin)* 6: 414 (1793); *Microlepia chinensis* (L.) Mett., *Fil. Hort. Bot. Lips*. 103 (1856); *Lindsaea chinensis* (L.) A.Braun & C.D.Bouché, *Index Seminum [Berlin]* 1866: 4 (1866); *Stenoloma chinensis* (L.) Bedd., *Handb. Ferns Brit. Ind.* 70, t. 34 (1883); *Sphenomeris chinensis* (L.) Maxon, *J. Wash. Acad. Sci*. 3: 144 (1913)
Type: CHINA, *Osbeck s.n.*, neotype S-P [5701], designated by Kramer (1971, first-step) and Mazumdar (2016a, second-step).
Voucher: Vanikoro, 20–150 m, 21 Jun 2016, *Chen et al. SITW11046*, BSIP!, TAIF [498856!], TNM!

Odontosoria deltoidea (C.Chr.) Lehtonen & Tuomisto, *Bot. J. Linn. Soc.* 163(3): 334 (2010). T, D
Lindsaea elongata Labill., *Sert. Austro-Caledon*. 6, t.9 (1824), *non* Cav., *Descr. Pl*. 265 (1802); *Lindsaea deltoidea* C.Chr., *Index Filic*. 393 (1906); *Sphenomeris deltoidea* (C.Chr.) Copel., *Univ. Calif. Publ. Bot.* 14: 366 (1929); *Stenoloma deltoideum* (C.Chr.) C.Chr., *Index Filic. Suppl. Tert*. 173 (1934)
Type: NEW CALEDONIA, *Labillardiére s.n.*, lectotype: P [00633680*], designated by Kramer (1967b); isolectotypes: B [20 0144817*], FI [004198*], P [00633679].
Voucher: San Jorge, 20–450 m, 6 Jun 2016, *Chen et al. SITW10502*, BSIP!, TAIF [520065!], TNM!

Odontosoria retusa (Cav.) J.Sm., *Bot. Voy. Herald* 10: 430 (1857). R, N
Davallia retusa Cav., *Descr. Pl*. 278 (1802); *Stenoloma retusum* Fée, *Mém. Foug.* 5: 330

[*Gen. Filic.*] (1852); *Lindsaea retusa* (Cav.) Mett., *Fil. Hort. Bot. Lips.* 105 (1856); *Schizoloma retusum* (Cav.) Kuhn, *Chaetopterides* 346 (1882); *Sphenomeris retusa* (Cav.) Maxon, *J. Wash. Acad. Sci.* 3: 144 (1913)
Type: PHILIPPINES (Luzon), *Née s.n.*, holotype: MA [475620*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10487*, BSIP!, TAIF [519890!] [519891!] [519892!], TNM!

OSMOLINDSAEA (K.U.Kramer) Lehtonen & Christenh., *Bot. J. Linn. Soc.* 163(3): 335 (2010)
Osmolindsaea minor (Hook.) Lehtonen & Christenh., *Syst. Bot.* 38(4): 896 (2014). R, E
Lindsaea cultrata (Willd.) Sw. var. *minor* Hook., *Sp. Fil.* 1: 204 (1846)
Type: PHILIPPINES (Luzon), *Cuming 65*, lectotype: K [000116239!], designated by Lehtonen et al. (2013); isolectotypes: L [0051825!] [3560648!], Z [000002177!].
Voucher: Kolombangara, 600–700 m, 5 Nov 2013, *Chen et al. SITW04060*, BSIP!, TAIF [459954!], TNM!

TAPEINIDIUM (C.Presl) C.Chr., *Index Filic.* 631 (1906)
Tapeinidium denhami (Hook.) C.Chr., *Index Filic.* 209 (1905). T, D
Davallia denhami Hook., *Sec. Cent. Ferns*, t. 47 (1860); *Microlepia denhami* (Hook.) T.Moore, *Index Fil.* 292 (1861); *Lindsaea denhami* (Hook.) Mett. ex Kuhn, *Verh. K.K. Zool.-Bot. Ges. Wien* 19: 573 (1869); *Wibelia denhami* (Hook.) Kuhn, *Chaetopterides* 346 (1882)
Type: FIJI, *Milne 116*, holotype: K [000913992*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10444*, BSIP!, TAIF [519933!], TNM!

Tapeinidium melanesicum K.U.Kramer, *Blumea* 15: 555 (1967). T, D
Type: SOLOMON ISLANDS (Santa Isabel), *Stone 2512*, holotype: U [0007354*]; isotypes: BISH [1000588*], US [00134926*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10425*, BSIP!, TAIF [519460!], TNM!

Tapeinidium novoguineense K.U.Kramer, *Blumea* 15: 550 (1967). T, E
Type: PAPUA NEW GUINEA (West or East Sepik Provinces, Torricelli Mountains), *Schlechter 14319*, holotype: B [20 0097702*] [20 0097703*]; isotypes: BM, BO, BR [0000006985202*], K [000361109*] [000361110*], P [00633657*] [P00633658*].
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04904*, BSIP!, TAIF [463849!], TNM!

PTERIDACEAE E.D.M.Kirchn., *Schul-Bot.* 109 (1831)
ACROSTICHUM L., *Sp. Pl.* 2: 1067 (1753)
Acrostichum speciosum Willd., *Sp. Pl.*, ed. 4, 5(1): 117 (1810). T, T
Type: INDIA, *Klein s.n.*, holotype: B-W [19541010*].
Voucher: Tetepare, 0–200 m, 24 Aug 2013, *Chen et al. SITW03349*, BSIP!, TAIF [448688!], TNM!

ADIANTUM L., *Sp. Pl.* 2: 1094 (1753)
Adiantum aneitense Carruth., *Fl. Vit.* 346 (1873). R, N

Type: VANUATU, *MacGillivray 110*, holotype: BM [001044139*]; isotype: BR [0000006590963*].
Voucher: Kolombangara, 600–700 m, 5 Nov 2013, *Chen et al. SITW04042*, BSIP!, TAIF [459963!] [459964!] [459965!] [459966!], TNM!

Adiantum diaphanum Blume, *Enum. Pl. Javae* 2: 215 (1828). R, S
Type: INDONESIA (Java), *Blume 649*, lectotype: L [0050898*], designated by Bostock (1998, first-step) and Field (2020, second-step); isolectotype: L [0050899*].
Voucher: Kolombangara, 600–700 m, 5 Nov 2013, *Chen et al. SITW04041*, BSIP!, TAIF [459750!], TNM!

Adiantum monosorum Baker, *Syn. Fil*., ed. 2, 472 (1874). T, E
Type: SOLOMON ISLANDS, *Macleay s.n*., holotype: K [000853569*].
Voucher: San Jorge, 20–450 m, 6 Jun 2016, *Chen et al. SITW10505*, BSIP!, TAIF [498610!] [519885!], TNM!

Adiantum philippense L., *Sp. Pl.* 2: 1094 (1753). R, T
Type: PHILIPPINES (Luzon), lectotype: Petiver *Gazophyl. Nat*. 8, t. 4, f. 4 (1702–1709), designated by Pichi Sermolli (1957).
Voucher: Guadalcanal, 230 m, 25 Jun 2015, *Chen et al. SITW06768*, BSIP!, TAIF [482727!] [519885!], TNM!, VT!
Note: *Adiantum philippense* is a species complex that includes several infraspecific taxa with different cytotypes and reproductive modes (Verma & Fraser-Jenkins, 2008). Solomon Islands plants produce 64 spores per sporangium, indicating sexual reproduction (three sporangia counted by C.-W. Chen). Future study is needed to confirm its ploidy and infraspecific identification.

Adiantum tenerum Sw., *Prodr*. 135 (1788). R, T
Type: JAMAICA, *Swartz s.n*., holotype: S [06-1895*].
Voucher: Guadalcanal, 10 m, 6 Jan 1992, *Glenny 3449*, BSIP!, WELT [P017390!].
Note: Naturalised in Solomon Islands, native to the Neotropics (Mexico to Costa Rica, Antilles, and Venezuela).

ANTROPHYUM Kaulf., *Enum. Filic*. 197, 282 (1824)
Antrophyum callifolium Blume, *Enum. Pl. Javae* 2: 111 (1828). E, S
Type: INDONESIA (Java), *Blume s.n*., lectotype: L [0050962*], designated by Jones (1998, first-step) and Lindsay & Middleton (2020, second-step).
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10540*, BSIP!, TAIF [520510!], TNM!

Antrophyum megistophyllum Copel., *Philipp. J. Sci*. 60: 113, t. 23 (1936). E, B
Type: SOLOMON ISLANDS (Makira), *Brass 3003*, holotype: PNH, destroyed; lectotype: GH [00020482*], designated here by Chen; isolectotype: BRI-AQ [0175484*].
Voucher: Makira, 910 m, 1 Jul 2015, *Chen et al. SITW06907*, BSIP!, TAIF [482582!], TNM!, VT!
Note: The only two known isotypes in BRI and GH do not bear Copeland's annotation and thus probably were not seen by him; we selected the more complete one in GH as lectotype.

Antrophyum

plantagineum (Cav.) Kaulf., *Enum. Filic.* 197 (1824). E, O
Hemionitis plantaginea Cav., *Descr. Pl.* 260 (1802), *nom. cons.*
Type: PHILIPPINES (Luzon), *Nee s.n.*, lectotype: MA [228176*], designated by Mazumdar (2015); isolectotype: MA [228177*].
Voucher: Makira, 910 m, 1 Jul 2015, *Chen et al. SITW06817*, BSIP!, TAIF [482765!], TNM!, VT!

Antrophyum solomonense C.W.Chen & J.H.Nitta, *Syst. Bot.* 40(3): 648 (2015). E, B
Type: SOLOMON ISLANDS (Santa Isabel), *Chen et al. SITW05633*, holotype: BSIP!; isotypes: GH!, K!, P!, TAIF [451874!], TNM!, US!
Voucher: Kolombangara, 600–700 m, 5 Nov 2013, *Chen et al. SITW04045*, BSIP!, TAIF [459765!], TNM!

Antrophyum subfalcatum Brack., *U.S. Expl. Exped., Filic.* 16: 65 (1854). E, J
Type: FIJI, *Wilkes Explor. Exped. 6*, lectotype: US [00134496!], designated by Brownlie (1977); isolectotype: YU [000686*].
Voucher: Kolombangara, 600–700 m, 5 Nov 2013, *Chen et al. SITW04047*, BSIP!, TAIF [459767!], TNM!
Note: After examining the type and other materials of both *A. smithii* and *A. subfalcatum*, we conclude that they are conspecific; *A. subfalcatum* has priority. The plant identified as *A. smithii* C.Chr. in Chen et al. (2017a) therefore belongs here.

AUSTROGRAMME E.Fourn., *Ann. Sci. Nat., Bot.*, sér. 5, 18: 278 (1873)
Austrogramme decipiens (Mett.) Hennipman, *Fern Gaz.* 11: 71 (1975). R, C
Gymnogramma decipiens Mett., *Ann. Sci. Nat., Bot.*, sér. 4, 15: 60 (1861); *Aspleniopsis decipiens* (Mett.) Kuhn, *Chaetopterides* 325 (1882)
Type: NEW CALEDONIA, *Vieillard 1648*, lectotype: P [00607825*], designated by Brownlie (1969); isolectotypes: GH [00021277*], MEL [295789*], NY [01085457*], P [00607824*].
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10576*, BSIP!, TAIF [499303!] [520574!], TNM!
Note: Our unpublished data show that a plant (*Chen et al. SITW11085*) given as *Syngramma* sp. in Chen et al. (2017a: 254–255) is likely a hybrid between this species and *S. quinata* (Hook.) Carruth.

CERATOPTERIS Brongn., *Bull. Sci. Soc. Philom. Paris* 1821: 186 (1821)
Ceratopteris thalictroides (L.) Brongn., *Bull. Sci. Soc. Philom. Paris* 1821: 186. (1821). A, T
Acrostichum thalictroides L., *Sp. Pl.* 2: 1070 (1753)
Type: SRI LANKA, *Hermann Herbarium 3: 42, specimen 377*, lectotype: BM [000621958*], designated by Pichi-Sermolli (1957).
Voucher: Kolombangara, 5 m, 2 Apr 2017, *Hsu et al. SITW13180*, BSIP!, TAIF!, TNM!

CHEILANTHES Sw., *Syn. Fil.* 5, 126 (1806)
Cheilanthes tenuifolia (Burm.f.) Sw., *Syn. Fil.* 129, 332 (1806). T, S
Trichomanes tenuifolia Burm.f., *Fl. Indica* 237 (1768)
Type: SRI LANKA, *s.c., s.n.*, lectotype: G-PREL [00349568], designated by Mazumdar

et al. (2019).
Voucher: Guadalcanal, 50–200 m, 23 Jul 2014, Chen et al. *SITW05694*, BSIP!, TAIF [473063!], TNM!

CONIOGRAMME Fée, *Mém. Foug.* 5: 167 [*Gen. Filic.*] (1852), *nom. cons.*
Coniogramme fraxinea (D.Don) Fée ex Diels, *Nat. Pflanzenfam.* 1(4): 262 (1899). T, R
Diplazium fraxineum D.Don, *Prodr. Fl. Nepal.* 12-13 (1824); *Gymnogramma fraxinea* (D.Don) Bedd., *Suppl. Ferns Brit. Ind.* 24 (1876); *Syngramma fraxinea* (D.Don) Bedd., *Handb. Ferns Brit. Ind.* 386 (1883); *Neurogramma fraxinea* (D.Don) Christ, *Farnkr.* 63 (1897 as "*Neurogramme*")
Type: NEPAL, *Hamilton s.n.*, lectotype: CAL, designated by Fraser-Jenkins et al. (2015).
Voucher: Kolombangara, 600–700 m, 5 Aug 2013, *Chen et al. SITW03005*, BSIP!, TAIF [445111!], TNM!

HAPLOPTERIS C.Presl, *Tent. Pterid.* 141 (1836)
Haplopteris dareicarpa (Hook.) S.Linds. & C.W.Chen, *Gard. Bull. Singapore* 66(2): 171 (2014). E, I
Monogramma dareicarpa Hook., *Sp. Fil.* 5: 121, t. 288A (1864)
Type: MALAYSIA (Sabah), *Barber 141*, lectotype: K [000959985*], designated here by Chen; isolectotype: B [20 0124469!], NY [02361696*].
Voucher: Kolombangara, 300–500 m, 16 Jan 2019, *Chen Wade5514*, TAIF!
Note: We selected the sheet in Hooker's herbarium in K as lectotype.

Haplopteris elongata (Sw.) E.H.Crane, *Syst. Bot.* 22(3): 514 (1998). E, T
Vittaria elongata Sw., *Syn. Fil.* 109, 302 (1806)
Type: INDIA, *Rottler 402*, holotype: S-P [5129*].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10552*, BSIP!, TAIF [520538!], TNM!

Haplopteris ensiformis (Sw.) E.H.Crane, *Syst. Bot.* 22(3): 514 (1998). E, T
Vittaria ensiformis Sw., *Neue Schriften Ges. Naturf. Freunde Berlin* 2: 134, t. 7 (1799)
Type: MAURITIUS, *Sonnerat s.n.*, holotype: SBT [1.1.8.53*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10432*, BSIP!, TAIF [519464!], TNM!

Haplopteris scolopendrina (Bory) C.Presl, *Tent. Pterid.* 141, t.5, f.21 (1836). E, T
Pteris scolopendrina Bory, *Voy. Iles Afrique* 2: 323 (1804); *Pteropsis scolopendrina* (Bory) Desv., *Mém. Soc. Linn. Paris* 6(3): 218 (1827); *Vittaria scolopendrina* (Bory) Mett., *Fil. Hort. Bot. Lips.* 25 (1856 as "*scolopendrioides*")
Type: RÉUNION, *Bory s.n.*, lectotype: P [00483411*], designated by Lindsay & Middleton (2020); isolectotype: P [00483410*].
Voucher: Kolombangara, 300–600 m, 17 Oct 2013, *Chen et al. SITW04959*, BSIP!, TAIF [463865!], TNM!

ONYCHIUM Kaulf., *Berlin. Jahrb. Pharm. Verbundenen Wiss.* 21: 45 (1820)
Onychium siliculosum (Desv.) C.Chr., *Index Filic.* 20 (1905). T, Q
Pteris siliculosa Desv., *Mag. Neuesten Entdeck. Gesammten Naturk. Ges. Naturf. Freunde Berlin* 5: 324 (1811); *Phorolobus siliculosus* (Desv.) Desv., *Mém. Soc. Linn.*

Paris 6: 291 (1827)
Type: UNKNOWN, *s.c., s.n.*, holotype: P [00584034*].
Voucher: Guadalcanal, 112 m, 8 Jul. 2015, *Huang et al. SITW07407*, BSIP!, TAIF [487612!] [487613!], TNM!
Note: This is a newly recorded genus and species for the Solomon Islands. The type locality was erroneously labelled as "America australi" (Fraser-Jenkins et al., 2017).

PITYROGRAMMA Link, *Handbuch* 3: 19–20 (1833)
Pityrogramma calomelanos (L.) Link, *Handbuch* 3: 20 (1833). T, T
Acrostichum calomelanos L., *Sp. Pl.* 2: 1072 (1753)
Type: CENTRAL AMERICA, *s.c., s.n.*, lectotype: LINN-HL [1245-19*], designated by Schelpe (1969).
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10417*, BSIP!, TAIF [519492!], TNM!
Note: The photographs of this species in Chen et al. (2017a) were erroneously cited as *SITW10418*. They all belong to *SITW10417*. Naturalised in Solomon Islands.

PTERIS L., *Sp. Pl.* 2: 1073 (1753)
Pteris comans G.Forst., *Fl. Ins. Austr.* 79 (1786). T, J
Type: VANUATU, *Forster s.n.*, lectotype: K [000785110*], designated by Nicolson & Fosberg (2004), isolectotypes: BM [001048441*], GOET [012784*] [012785*], LE [00008605*], PH [00050032*].
Voucher: Kolombangara, 600–700 m, 5 Aug 2013, *Chen et al. SITW02973*, BSIP!, TAIF [445137!], TNM!

Pteris ensiformis Burm.f., *Fl. Indica* 230 (1768). T, S
Type: INDONESIA (Java), *Pryon s.n.*, lectotype: G-PREL [00360108*], designated by Mazumdar et al. (2019).
Voucher: Guadalcanal, 50–200 m, 23 Jun 2014, *Chen et al. SITW05706*, BSIP!, TAIF [472185!] [472186!], TNM!

Pteris ligulata Gaudich., *Voy. Uranie* 385 (1829). T, I
Type: INDONESIA (Indonesian New Guinea, Rawak), *Gaudichaud s.n.,* lectotype: P [00610508*], designated here by Chao; isolectotypes: B [20 0033828*], FI [004242*], K [000472673*], P [00610507*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10419*, BSIP!, TAIF [519491!], TNM!
Note: There is a discrepancy on the locality cited in the protologue as "Vaigiou" [Waigeo] and on the original materials as "Rawak". Rawak is a much smaller island located ca. 500 m north of Waigeo island. There are two sheets of original material in P, each with single frond; we selected the sheet with the larger frond as lectotype.

Pteris macrophylla Copel., *Univ. Calif. Publ. Bot.* 18: 218 (1942). T, D
Type: PAPUA NEW GUINEA, Brass 10298, holotype: MICH [1190956*]; isotypes: BO [1352718*], GH [00021995*], L [0052044*] [0052045*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015*, Chen et al. SITW07566*, BSIP!, TAIF [486643!], TNM!, VT!
Note: Newly recorded from the Solomon Islands. It can be distinguished from the

common *P. tripartita* by the venation; *P. macrophylla* has areolae only along the costules, and not along the midveins of the segments.

Pteris pacifica Hieron., *Hedwigia* 55: 355 (1914). T, K
Type: FIJI, *Kleinschmidt 36*, lectotype: B [20 0097772*], designated by Field (2020).
Voucher: Makira, 910 m, 1 Jul 2015, *Chen et al. SITW06885*, BSIP!, TAIF [482830!], TNM!

Pteris papuana Ces., *Rendiconto Reale Accad. Sci. Fis.* 16: 25, 29 (1877). T, N
Type: PAPUA NEW GUINEA (Indonesian New Guinea, Mt. Arfak), *Beccari s.n.*, holotype: FI [013649*]; isotypes: BM [000592379*], K [000474840*] [000474841*].
Voucher: Guadalcanal, 50–200 m, 23 Jun 2013, *Chen et al. SITW05699*, BSIP!, TAIF [472997!] [472998!], TNM!

Pteris polylepis (M.Kato & K.U.Kramer) Y.S.Chao, *comb. et stat. nov.* T, E
Pteris mertensioides Willd. subsp. *polylepis* M.Kato & K.U.Kramer, *Acta Phytotax. Geobot.* 41(4-6): 161 (1990)
Type: INDONESIA (Maluku, Seram), *Kato et al. C-1583*, holotype: TI; isotypes: BO, KYO, L [3601873*], MICH, MO [3812068*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11603*, BSIP! TAIF [498929!], TNM!
Note: Our unpublished data showed there was a considerable genetic divergence between *P. mertensioides* and var. *polylepis*; therefore it was better to recognise the latter at species rank. Newly recorded from the Solomon Islands.

Pteris terminalis Wall. ex J.Agardh var. ***terminalis***, *Recens. Spec. Pter.* 20 (1839). T, R
Type: NEPAL, *Wallich Cat. No. 101.1*, lectotype: K [001109252*], designated by Fraser-Jenkins (2008).
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05381*, BSIP!, TAIF [471891!], TNM!
Note: This species was identified as *P. torricelliana* Christ in Chen et al. (2017a), but here we follow the synonymisation by Ebihara et al. (2017).

Pteris tripartita Sw., *J. Bot. (Schrader)* 1800(2): 67 (1801). T, T
Litobrochia tripartita (Sw.) C.Presl, *Tent. Pterid.* 150 (1836)
Type: INDONESIA (Java), *Thunberg s.n.*, lectotype: UPS-THUNB [24969], designated by Piu & Mazumdar (2019); isolectotype: UPS-THUNB [24968].
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05618*, BSIP!, TAIF [472975!], TNM!

Pteris vitiensis Baker, *J. Bot.* 17: 295 (1879). T, D
Type: FIJI (Viti Levu), *Horne 718*, lectotype: K [000757493*], designated by Brownlie (1977); isolectotypes: K [000757492*], GH [00022007*].
Voucher: Guadalcanal, 400–1000 m, 30 Jun 2014, *Chen et al. SITW05282*, BSIP!, TAIF [464772!] [464773!] [464774!] [464775!] [464776!], TNM!

Pteris vittata L., *Sp. Pl.* 2: 1074 (1753). T, T
Type: CHINA (Guangdong), *Osbeck s.n.*, lectotype: LINN [1246.3], designated by Tryon

(1964).
Voucher: Vanikoro, 20–250 m, 20 Jun 2016, *Chen et al. SITW11029*, BSIP!, TAIF!, TNM!

Pteris warburgii Christ, *Monsunia* 1: 70 (1900). T, E
Type: INDONESIA (Maluku, Ambon), *Warburg 17580*, holotype: B [20 0090073*]; isotype: BM [000592356*].
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05618*, BSIP!, TAIF [472975!], TNM!

Pteris werneri (Rosenst.) Holttum, *Kew Bull.* 20(3): 457, f.2 (1967). T, N
Hemipteris werneri Rosenst., *Repert. Spec. Nov. Regni Veg.* 5: 38 (1908)
Type: PAPUA NEW GUINEA, *Werner 2*, holotype: B [20 0127573*]; isotypes: BM [000592357*], NY [00127504*], UC [391447*].
Voucher: Vanikoro, 430 m, 29 Jun 2016, *Chen et al. SITW11092*, BSIP!, TAIF [498964!] [498965!] [498966!] [498967!] [498968!], TNM!

SYNGRAMMA J.Sm., *London J. Bot.* 4: 168 (1845)
Syngramma borneensis (Hook.) J.Sm., *Hist. Fil.* 152 (1875). T, I
Gymnogramma borneensis Hook., *Sp. Fil.* 5: 154, t. 301 (1864); *Toxopteris borneensis* (Hook.) Trevis., *Atti Reale Ist. Veneto Sci. Lett. Arti*, ser.5, 3: 591 (1877); *Trichiogramme borneensis* (Hook.) Kuhn, *Chaetopterides* 326 (1882)
Type: MALAYSIA (Sarawak), *Lobb s.n.*, lectotype: K [001057904*], designated here by Chen; isolectotypetype: B [20 0147070*], K [000443258*].
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10579*, BSIP!, TAIF [520569!], TNM!
Note: There are two syntypes in Hooker's herbarium in K, and we selected as lectotype the one bearing the same "On trees, Sarawak, 2500 ft" locality as in the protologue.

Syngramma quinata (Hook.) Carruth., *Fl. Vit.* 372 (1873). T, N
Gymnogramma quinata Hook., *Sp. Fil.* 5: 152, t. 297 (1864); *Dictyogramme quinata* (Hook.) Trevis., *Atti Reale Ist. Veneto Sci. Lett. Arti,* ser. 5, 3: 591 (1877); *Trichiogramme quinata* (Hook.) Kuhn, *Chaetopterides* 328 (1882); *Neurogramma quinata* (Hook.) Christ, *Farnkr.* 64 (1897); *Craspedodictyum quinatum* (Hook.) Copel., *Philipp. J. Sci., C.* 6: 85 (1911)
Type: SOLOMON ISLANDS (Vanikoro), *Moore 12*, lectotype: K [001057902*], designated by Holttum (1975a); isolectotype: B [20 0121054*].
Voucher: San Jorge, 20–150 m, 13 Jun 2016, *Chen et al. SITW10427*, BSIP!, TAIF [519461!], TNM!
Note: Our unpublished data showed that the plants (*Chen et al. SITW05770* and *Chen et al. SITW10429*) identified as *S. spathulata* (C.Chr.) Holttum in Chen et al. (2017a) are not that species. Instead, they are likely a hybrid between *S. quinata* and an unknown species.

TAENITIS Willd. ex Schkuhr, *24. Kl. Linn. Pfl.-Syst.* 20 (1809)
Taenitis blechnoides (Willd.) Sw., *Syn. Fil.* 24, 220 (1806). T, S
Pteris blechnoides Willd., *Phytographia* 13, t. 9, f. 3 (1794)
Type: INDIA, *Klein 14*, holotype: B-W [19577010*].

Voucher: Guadalcanal, 400–1000 m, 30 Jun 2014, *Chen et al. SITW05281*, BSIP!, TAIF [464771!], TNM!
Note: Our unpublished data suggested that Solomon Islands plants are distantly related to *T. blechnoides* from Asia and should be recognised as a different species. However, their morphological delimitation is not yet clear.

Taenitis diversifolia Holttum, *Blumea* 16: 93 (1968). T, D
Platytaenia diversifolia (Holttum) Pic.Serm., *Webbia* 29: 7 (1974)
Type: SOLOMON ISLANDS (Kolombangara), *Braithwaite RSS 4360*, holotype: K [001057884*] [001057885*]; isotype: BSIP!
Voucher: San Jorge, 20–150 m, 13 Jun 2016, *Chen et al. SITW10427*, BSIP!, TAIF [519461!], TNM!
Note: Two sheets in K are clearly labelled as being part of a single specimen and constitute the holotype, in accordance with ICN Art. 8.3 (Turland et al., 2018). Our unpublished data showed that a plant (*Chen et al. SITW10441*) cited as *Taenitis* sp. in Chen et al. (2017a: 258) is likely of hybrid origin between *T. diversifolia* and an unknown species.

Taenitis hookeri (C.Chr.) Holttum, *Kew Bull*. 30: 334 (1975). T, N
Hemionitis lanceolata Hook., *Sec. Cent. Ferns*, t.55 (1861), *non* L., *Sp. Pl.* 2: 1077 (1753); *Trichiogramme lanceolata* (Hook.) Kuhn, *Chaetopterides* 328 (1882); *Syngramma lanceolata* (Hook.) Diels, *Nat. Pflanzenfam*. 1(4): 257 (1899); *Syngramma hookeri* C.Chr., *Index Filic*. 346 (1905); *Taenitis lanceolata* (Hook.) Holttum, *Blumea* 16: 91 (1968)
Type: FIJI, *Milne s.n.*, holotype: K [001057882*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW06948*, BSIP!, TAIF [482808!], TNM!
Note: This species was misplaced under *Syngramma* in Chen et al. (2017a).

VAGINULARIA Fée, *Mém. Foug*. 3: 30 [*Hist. Vittar. Pleurogr.*] (1852)
Vaginularia acrocarpa Holttum, *Dansk Bot. Ark*. 25: 51 (1967). E, O
Monogramma acrocarpa (Holttum) D.L.Jones, *Fl. Australia* 48: 709 (1998)
Type: PAPUA NEW GUINEA (Bismarck Archipelago), *Dissing & Olsen 2352*, holotype: C [10009187*]; isotype: K [000959982*].
Voucher: Kolombangara, 1200–1700 m, 29 Jul 2013, *Chen et al. SITW02964*, BSIP!, TAIF [445130!], TNM!

Vaginularia junghuhnii Mett., *Fil. Hort. Bot. Lips*. 25, t.27, f.24-28 (1856). E, P
Monogramma junghuhnii (Mett.) Hook., *Sp. Fil*. 5: 123, t.289B (1864)
Type: INDONESIA (Java), *Zollinger 1890*, holotype: B [20 0097310*].
Voucher: Vella Lavella, 312–775 m, 28 Oct 2013, *Chen et al. SITW04026*, BSIP!, TAIF [459762!], TNM!
Note: Photos of this species were erroneously called *V. acrocarpa* in Chen et al. (2017a).

DENNSTAEDTIACEAE Lotsy, *Vort. Bot. Stammesgesch*. 2: 655 (1909)
DENNSTAEDTIA Bernh., *J. Bot. (Schrader)* 1800(2): 124 (1801)
Dennstaedtia flaccida (G.Forst.) Bernh., *J. Bot. (Schrader)* 1800(2): 124, t.1, f.3 (1801). T, C

Trichomanes flaccidum G.Forst., *Fl. Ins. Austr.* 85 (1786); *Cyathea flaccida* (G.Forst.) Spreng., *J. Bot.* 1799(2): 271 (1799); *Dicksonia flaccida* (G.Forst.) Sw., *J. Bot. (Schrader)* 1800(2): 90 (1801); *Microlepia flaccida* (G.Forst.) Fée, *Mém. Foug.* 5: 327 [*Gen. Filic.*] (1852)
Type: VANUATU, *Forster s.n.*, lectotype: BM [001048451*, 001048452*], designated by Tryon and Tryon (1980).
Voucher: Guadalcanal, 13 Sep 2015, *Perrie & Renner 7288*, WELT [P028460!].
Note: Newly recorded from the Solomon Islands.

Dennstaedtia glabrata (Ces.) C.Chr., *Index Filic.* 217 (1905). T, E
Dicksonia glabrata Ces., *Rendiconto Reale Accad. Sci. Fis.* 16: 24, 28 (1877); *Paradennstaedtia glabrata* (Ces.) Tagawa, *J. Jap. Bot.* 27: 213 (1952)
Type: INDONESIA (Indonesian New Guinea), *Beccari s.n.*, holotype: FI [013611*, 2 sheets]; isotype: K [000429847*].
Voucher: Vanikoro, 600 m, 27 Jun 2016, *Chen et al. SITW11084*, BSIP!, TAIF [498975!] [498976!], TNM!
Note: *Dennstaedtia tripinnatifida* Copel., described from Makira, is a synonym of this species.

Dennstaedtia samoensis (Brack.) T.Moore, *Index Fil.* 307 (1857). T, N
Sitolobium samoense Brack., *U.S. Expl. Exped., Filic.* 16: 274, t. 38, f. 1 (1854); *Dicksonia samoensis* (Brack.) Baker, *Syn. Fil.*, ed. 2, 462 (1874)
Type: SAMOA, *Wilkes Explor. Exped. s.n.*, holotype: US [00134859*].
Voucher: Guadalcanal, 400–1000 m, 30 Jun 2014, *Chen et al. SITW05295*, BSIP!, TAIF [464789!], TNM!

Dennstaedtia zeylanica (Sw.) Zink ex Fraser-Jenk. & Kandel, *Ferns Fern-Allies Nepal* 1: 161 (2015). T, P
Dicksonia zeylanica Sw., *J. Bot. (Schrader)* 1800(2): 91 (1801); *Microlepia zeylanica* (Sw.) C.Presl, *Epimel. Bot.* 96 (1851 ['1849'])
Type: SRI LANKA, *Thunberg s.n.*, holotype: S-P [10467*].
Voucher: Kolombangara, 20 m, 11 Aug 1991, *Glenny 3155*, BSIP!, WELT [P017059!].
Note: This species has been widely known as *Dennstaedtia scabra* (Wall. ex Hook.) T.Moore, but here we follow Fraser-Jenkins et al. (2015) who found that *D. zeylanica* is the earliest name for this species.

HISTIOPTERIS (J.Agardh) J.Sm., *Hist. Fil.* 294 (1875)
Histiopteris herbacea Copel., *Philipp. J. Sci.* 60: 110, t.18 (1936). T, A
Type: SOLOMON ISLANDS (Santa Isabel), *Brass 3337*, holotype: PNH, destroyed; lectotype: GH [00021310*], designated here by Chen; isolectotypes: BISH [104047*], BRI [AQ0020369*], P [00633343*].
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10567*, BSIP!, TAIF [520577!], TNM!
Note: Endemic. Four duplicates of *Brass 3337* are known; we selected the one in GH with Copeland's annotation as lectotype. This species may be conspecific with *H. stipulacea* (Hook.) Copel., which is known from Malesia including New Guinea.

Histiopteris incisa (Thunb.) J.Sm., *Hist. Fil.* 295 (1875). T, T

Pteris incisa Thunb., *Prodr. Fl. Cap.*, pt. 2: 171 (1800); *Litobrochia incisa* (Thunb.) C.Presl, *Tent. Pterid.* 149 (1836); *Phegopteris incisa* (Thunb.) Keyserl., *Polyp. Herb. Bunge* 51 (1873)
Type: SOUTH AFRICA (Cape of Good Hope), *Thunberg s.n.*, lectotype: UPS-THUNB [24932*], designated by Brownsey (1998); isolectotype: S-P [7759*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11143*, BSIP!, TNM!
Note: Shinohara et al. (2021) found that more than one species are included in the current species circumscription. Further study is needed to confirm if the Solomon Islands plants are identical to those from the type locality.

HYPOLEPIS Bernh., *Neues J. Bot.* 1(2): 34 (1805)
Hypolepis elegans Carruth. subsp. ***elegans***, *Fl. Vit.* 347 (1873). T, J
Type: VANUATU, *MacGillivray 108*, lectotype: BM [001048154*], designated by Brownlie (1977); isolectotype: E [00205308*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11128*, BSIP!, TNM!

MICROLEPIA C.Presl, *Tent. Pterid.* 124, pl. 4, f. 21–23 (1836)
Microlepia speluncae (L.) T.Moore, *Index Fil.* 93 (1857). T, T
Polypodium speluncae L., *Sp. Pl.* 2, 1093 (1753); *Aspidium speluncae* (L.) Willd., *Sp. Pl.,* ed. 4, 5(1): 269 (1810); *Davallia speluncae* (L.) Baker, *Syn. Fil.* 100 (1868); *Dryopteris speluncae* (L.) Underw. ex Britton, *Fl. Bermuda* 426, (f. 466) (1918); *Scyphofilix speluncae* (L.) Farw., *Amer. Midl. Naturalist* 12: 263 (1931)
Type: SRI LANKA, *Herb. Hermann 3, 41, 384*, lectotype: BM [000621951*], designated by Sledge (1982).
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10486*, BSIP!, TAIF [519904!] [519905!] [519906!], TNM!

PTERIDIUM Gled. ex Scop., *Fl. Carniol.* 169 (1760)
Pteridium esculentum (G.Forst.) Cockayne subsp. ***esculentum***, *Rep. Tongariro Natl. Park* 34 (1908). T, S
Pteris esculenta G.Forst., *Pl. Esc.* 74 (1786); *Allosorus esculentus* (G.Forst.) C.Presl, *Tent. Pterid.* 154 (1836); *Pteris aquilina* L. var. *esculenta* (G.Forst.) Hook.f., *Fl. Nov.-Zel.* 2: 25 (1854); *Cincinalis esculenta* (G.Forst.) Trevis., *Atti Soc. Ital. Sci. Nat.* 17: 239 (1875); *Ornithopteris esculenta* (G.Forst.) J.Sm., *Hist. Fil.* 298 (1875); *Pteridium aquilinum* (L.) Kuhn var. *esculentum* (G.Forst.) Kuhn, *Chaetopterides* 27 (1882); *Pteridium aquilinum* (L.) Kuhn subsp. *esculentum* (G.Forst.) C.Chr., *Index Filic.* 591, 597 (1906)
Type: NEW ZEALAND, *Forster s.n.*, lectotype: BM [001048405*], designated by Brownsey (1989).
Voucher: San Jorge, 20–450 m, 6 Jun 2016, *Chen et al. SITW10503*, BSIP!, TAIF [498615!] [498616!] [519888!] [519917!], TNM!
Note: This species was misidentified as *P. aquilinum* (L.) Kuhn in Chen et al. (2017a). However, the voucher has free axial lobes, indicating that it should be called *P. esculentum* (Thomson, 2016).

DIPLAZIOPSIDACEAE X.C.Zhang & Christenh., *Phytotaxa* 19: 15 (2011)
DIPLAZIOPSIS C.Chr., *Index Filic.* 227 (1905)
Diplaziopsis javanica (Blume) C.Chr., *Index Filic.* 227 (1905). T, R

Asplenium javanicum Blume, *Enum. Pl. Javae* 2: 175 (1828); *Allantodia javanica* (Blume) Trevis., *Nuovo Giorn. Bot. Ital.* 7: 159 (1875); *Diplazium javanicum* (Blume) Makino, *Bot. Mag.* 20: 85 (1906); *Athyrium javanicum* (Blume) Copel., *Univ. Calif. Publ. Bot.* 16: 70 (1929)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L [0051525*], designated here by Chen; isolectotype: L [0051524*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07568*, BSIP!, TAIF [486641!], TNM!, VT!
Note: *Blume s.n.* in L comprises two sheets, and they are considered as duplicates because they are not clearly labelled as being part of a single specimen. We selected the one with a complete frond as lectotype.

ASPLENIACEAE Newman, *Hist. Brit. Ferns* 6 (1840)
ASPLENIUM L., *Sp. Pl.* 2: 1078 (1753)
Asplenium acrobryum Christ, *Nova Guinea* 8: 150 (1909). E, B
Type: INDONESIA (Indonesian New Guinea), *Versteeg 1439*, lectotype: P [00612307*], designated here by Ohlsen; isolectotypes: BO [1290663*], K [000448838*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07578*, BSIP!, TAIF [486600!], TNM!, VT!
Note: *Asplenium acrobryum* is similar to *A. amboinense* Willd. and may prove to be conspecific. The sheet in P is here designated as lectotype because it is a complete frond displaying the sori well and with several stipe scales.

Asplenium affine Sw., *J. Bot. (Schrader)* 1800(2): 56 (1801). E, R
Type: MAURITIUS, *Gröndahl s.n.,* holotype: S-P [784*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11591*, BSIP!, TNM!
Note: This name has been very widely used throughout the Old World tropics. Xu et al. (2020) showed that specimens from the Mascarene Islands were only distantly related to those from Asia, Malesia, and the Pacific Islands, suggesting that the species in the latter area might not be true *A. affine*. Our unpublished analysis of chloroplast DNA sequences showed that there is possibly more than one species within this complex in the Solomon Islands. Further sampling and study of the complex throughout its range is required to better understand species boundaries in this group. The *Asplenium* sp. in Chen et al. (2017a) is tentatively included here.

Asplenium amboinense Willd., *Sp. Pl.,* ed. 4, 5(1): 303 (1810). E, N
Type: INDONESIA (Maluku, Ambon), *Ventenat s.n.*, holotype: B-W [19865010*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10430*, BSIP!, TAIF [519463!], TNM!

Asplenium atrovirens (Hook.) Baker, *Syn. Fil.*, ed. 2, 484 (1874). R, B
Asplenium persicifolium J.Sm. var. *atrovirens* Hook., *Sp. Fil.* 3: 109 (1860)
Type: SOLOMON ISLANDS (Guadalcanal), *Milne 557*, holotype: K [000670165*] [K000670166*].
Voucher: Kolombangara, 600–700 m, 5 Aug 2013, *Chen et al. SITW03006*, BSIP!, TAIF [445110!], TNM!
Note: Dubiously distinct from *A. persicifolium* J.Sm., but we retained it here pending further research.

Asplenium baileyanum (Domin) Watts, *Proc. Linn. Soc. New South Wales* 39: 783 (1915). R, H
Asplenium hookerianum Colenso var. *baileyanum* Domin, *Biblioth. Bot.* 20 (85): 102 (1913)
Type: AUSTRALIA (Queensland), *Bailey s.n.*, lectotype: BRI-AQ [0144078*], designated by Field (2020); isolectotypes: K [001092573*], NSW [680989*], P [00642992*].
Voucher: Guadalcanal, 548 m [1800 ft], 23 Oct 1965, *Braithwaite RSS 4629*, BSIP! CANB.

Asplenium bipinnatifidum Baker, *Syn. Fil.* 221 (1868). E, N
Asplenium bipinnatum Brack., *U.S. Expl. Exped., Filic. 16: 344* (1854), *non* Roxb., *Calcutta J. Nat. Hist.* 4: 499 (1844)
Type: FIJI, *Wilkes Explor. Exped.* 52, lectotype: K [000668685*], designated here by Ohlsen; isolectotype: GH [00020520*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10446*, BSIP!, TAIF [519935!], TNM!
Note: The sheet in K was here chosen as lectotype because it bears Baker's annotation and includes the rhizome as well as the characteristic stolon.

Asplenium carruthersii Baker, *Syn. Fil.*, ed. 2, 483 (1874). T, D
Asplenium salignum Carruth., *Fl. Vit.* 354 (1873), *non* Blume, *Enum. Pl. Javae* 2: 175 (1828)
Type: FIJI, *Seemann 817*, holotype: K [000666242*].
Voucher: Guadalcanal, 50 m, 15 Jan 1992, *Glenny 3462*, BSIP!, WELT [P017393!].

Asplenium caudatum G.Forst., *Fl. Ins. Austr.* 80 (1786). E, O
Asplenium adiantoides Lam. var. *caudatum* (G.Forst.) Domin, *Biblioth. Bot.* 85: 97 (1913)
Type: PACIFIC ISLANDS, *Forster s.n.*, lectotype: BM [001048371*], designated here by Ohlsen; isolectotypes: GOET [012797*], LIV [9419], UPS-THUNB [24789] [24790].
Voucher: Vanikoro, 430 m, 29 Jun 2016, *Chen et al. SITW11091*, BSIP!, TNM!
Note: Several names exist for pinnate spleenworts with sori that run parallel to the midrib of the pinnae. Salgado (2020) reviewed the morphological variation within this group and recognised four species, *A. caudatum*, *A. horridum* Kaulf., *A. truncatilobum* (C.Presl) Fée and *A. truncatum* Blume, with the true *A. caudatum* being restricted to Tahiti. Under this circumscription, Solomon Island plants would belong to *A. horridum* Kaulf. However, all these species have also been included within *A. caudatum* (e.g., Mettenius 1859; Raciborski 1898; Christensen 1905–1906; Backer & Posthumus 1939; Ranker et al., 2019) and narrowly defined species concepts applied to this group of *Asplenium* introduce contradictions and complications summarised by Ohlsen (2020a). Unless further research utilizing DNA sequence data demonstrate that narrowly defined species concepts better represent separate lineages, it seems more practical to recognise this morphologically distinctive group as one species. The sheet in BM was selected as lectotype because it is an almost complete fertile frond and shows the diagnostic broad and sometimes truncate pinna lobes.

Asplenium cymbifolium Christ, *Bull. Herb. Boissier*, sér. 2, 6: 999 (1906). E, E
Neottopteris cymbifolia (Christ) Tagawa, *J. Jap. Bot.* 22: 161 (1949)
Type: PHILIPPINES (Luzon), *Loher s.n.*, lectotype: B [20 0013349*], designated here by Ohlsen; isolectotypes: K [000448059*] [000448060*].
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04921*, BSIP!, TAIF [464206!] [464207!] [464208!], TNM!
Note: The sheet in B was chosen as lectotype because it is a fully fertile frond with scales presented at the base of the stipe. Scales at the base of the stipe are an important character for identification in bird-nest *Asplenium* (Dong et al., 2012), but often become detached in herbarium specimens.

Asplenium falcatum Lam., *Encycl.* 2(1): 306 (1786). E, S
Tarachia falcata (Lam.) C.Presl, *Epimel. Bot.* 77 (1851 ['1849'])
Type: SRI LANKA, *Herb. Herm. t.43*, lectotype: BM [000621974*], designated by Salgado and Fraser-Jenkins (2013).
Voucher: Guadalcanal, 230 m, 25 Jun 2015, *Chen et al. SITW06770*, BSIP!, TAIF [482729!], TNM!
Note: This species was identified as *A. polyodon* G.Forst. in Chen et al. (2017a), but here we follow Salgado and Fraser-Jenkins (2013) who recognised plants from Asia as *A. falcatum*. Solomon Island plants have scale morphology that would likely place them in the same lineage as the Asian plants (i.e., the *A. listeri* clade of Ohlsen et al., 2014b).

Asplenium laserpitiifolium Lam., *Encycl.* 2(1): 310 (1786). E, S
Tarachia laserpitiifolia (Lam.) C.Presl, *Epimel. Bot.* 83 (1851 ['1849']); *Asplenium cuneatum* Lam. var. *laserpitiifolium* (Lam.) F.Muell., *Fragm.* 5: 131 (1865)
Type: PAPUA NEW GUINEA (New Ireland), *Commerson s.n.*, lectotype: P [00674582*] [00674583*] [00674584*], designated by Tardieu-Blot and Ching (1936); possible isolectotypes: MICH [1190071*], MPU [019862*] P [01555264*].
Voucher: Makira, 910 m, 1 Jul 2015, *Chen et al. SITW06821*, BSIP!, TAIF [482624!] [482625!], TNM!, VT!

Asplenium lobulatum Mett., *Linnaea* 36(1): 100 (1869). T, K
Chamaefilix lobulata (Mett.) Farw., *Amer. Midl. Naturalist* 12: 272 (1931)
Type: HAWAII, *Meyen s.n.,* lectotype: B [20 0017327*], designated here by Ohlsen.
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11653*, BSIP!, TNM!
Note: Similar plants from New Guinea have been described as *A. cromwellianum* Rosenst. and *A. ledermannii* Hieron., and in Australia as *A. athertonense* S.B. Andrews. Australian and New Guinean plants lack differences that could distinguish them from plants in the Pacific that have been included in *A. lobulatum* (Copeland 1949a; Ohlsen 2020b) and have been shown in phylogenies of chloroplast DNA sequences to be very closely related, with only minor sequence divergence among three regions sampled (Ohlsen et al., 2014a; Xu et al., 2020). Consequently, all these names are considered synonymous. Two syntypes in B are both complete fronds, and we selected the one that best matches the description in the protologue.

Asplenium marattioides (Brack.) C.Chr., *Bull. Bernice P. Bishop Mus.* 177: 66 (1943). E, N
Polybotrya marattioides Brack., *U.S. Expl. Exped., Filic.* 16: 79 (1854)

Type: SAMOA, *Wilkes Explor. Exped. 2*, holotype: US [00135103*].
Voucher: Guadalcanal, 230 m, 25 Jun 2015, *Chen et al. SITW06767*, BSIP!, TAIF [482726!], TNM!, VT!
Note: *Asplenium ludens* Baker, described from Makira, is a synonym of this species.

Asplenium musifolium Mett., *Abh. Senckenberg. Naturf. Ges.* 3(1): 130 (1859). E, L
Neottopteris musifolia J.Sm., *J. Bot.* 3: 409 (1841), *nom. nud.*; *Thamnopteris nidus* (L.) C.Presl var. *musifolia* (Mett.) Bedd., *Handb. Ferns Brit. Ind.* 139 (1883); *Asplenium nidus* L. var. *musifolium* (Mett.) C.Chr., *Index Filic.* 122 (1905)
Type: PHILIPPINES (Luzon), *Cuming 89*, holotype: K [000448048*] [000448049*] [000448050*].
Voucher: Guadalcanal, 600–13000 m, 23 Jul 2016, *Chen et al. SITW11625*, BSIP!, TNM!

Asplenium nigrescens Blume, *Enum. Pl. Javae* 2: 180 (1828). E, E
Type: INDONESIA (Maluku), *Reinwardt 1183*, holotype: L [0051021*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07577*, BSIP!, TAIF [486575!], TNM!, VT!
Note: The type of *A. nigrescens* is pinnate with serrate margins, sori densely situated near the midrib, and blades that dry a dark blackish colour on herbarium sheets. These features are shared among a group of *Asplenium* that bear small, often caducous, glandular hairs on the stipe and rachis. Numerous species have been described with this morphology, and it is not well established how these differ from each other and whether they are distinct. Plants from areas surrounding the Solomon Islands with this morphology (i.e., Australia, New Guinea and New Caledonia) have been shown to be closely related with only minor genetic divergence (Ohlsen et al., 2014a; Xu et al., 2020) and appear to constitute a single species that is probably conspecific with plants from the Solomon Islands. Whether similar plants identified as *A. contiguum* Kaulf. and *A. lepturus* J.Sm. from Hawaii and Vietnam, respectively, in Xu et al. (2020) are also best treated as conspecific with Solomon Island plants requires further evaluation. If the type of *A. nigrescens* is confirmed to bear the glandular hairs, that would firmly place it among this group of *Asplenium*. However, its use for Solomon Islands plants is based here on an assumption that *A. contiguum*, which is an earlier name, is distinct from Solomon Island plants and that *A. nigrescens* belongs to the lineage in the western Pacific and eastern Malesia rather than to the related lineage containing *A. contiguum* and *A. lepturus*. If *A. nigrescens* belongs to the lineage containing *A. contiguum* and *A. lepturus*, *A. parvum* Watts is the oldest name that is definitely attributable to the lineage in the western Pacific and eastern Malesia.

Asplenium oblanceolatum Copel., *Philipp. J. Sci., C.* 9: 229 (1914). E, P
Type: INDONESIA (Sumatra), *Brooks 28S*, holotype: MICH [1190077*]; isotype: P [01481243*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07584*, BSIP!, TNM!
Note: Bird-nest *Asplenium* from Malesia with echinate spores have been recognised as *A. phyllitidis* subsp. *malesicum* Holttum (e.g., Holttum, 1974a). Phylogenies of chloroplast data have shown these subspecies to be more closely related to other bird-nest *Asplenium* species than they are to each other (Dong et al., 2012) and so are worthy of recognition as separate species. *Asplenium oblanceolatum* is likely to be the earliest name at species rank for bird-nest *Asplenium* with echinate spores.

Asplenium pellucidum Lam., *Encycl.* 2(1): 305 (1786). E, T
Type: MAURITIUS, *Commerson s.n.*, lectotype: P [04022132*], designated by Field (2020); isolectotypes: P [04022133*] [04022134*] [01439039*] [01439064*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10467*, BSIP!, TAIF [519959!], TNM!

Asplenium powellii Baker, *Syn. Fil.* 224 (1868). T, N
Type: SAMOA, *Powell 44*, holotype: K [000672402*] [K000672403*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07567*, BSIP!, TAIF [486642!], TNM!, VT!
Note: Two specimens of *Powell 44* in K were recognised as the holotype because they are part of a very large frond, and this treatment is in accord with ICN Art. 8.3 (Turland et al., 2018).

Asplenium sancti-christofori Christ, *Fl. Deutsch. Südsee* 128 (1901). E, E
Type: PAPUA NEW GUINEA, *Lauterbach 2353*, holotype: S-P [1445*].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10534*, BSIP!, TAIF [498598!] [498599!] [498600!] [520612!] [520613!], TNM!

Asplenium scandens J.Sm. ex Mett., *Abh. Senckenberg. Naturf. Ges.* 3(1): 152 (1859). E, I
Darea scandens (J.Sm.) Fée, *Mém. Foug.* 5: 332 [*Gen. Filic.*] (1852)
Type: PHILIPPINES, *Cuming 297*, holotype: BM [001045256*]; isotypes: B [20 0021932*] [20 0021934*] [20 0021935*], BM [001045255*], GH [00020584*], K [000446728*] [000446729*] [000446739*], MICH [1191178*], P [00642944!] [00642945*] [00642946*], US [00135116*].
Voucher: Choiseul, 0 m, 14 Jun 2013, *Hu et al. SITW02625*, BSIP!, TAIF [445834!], TNM!

Asplenium schizocarpum (Copel.) Copel., *Ann. Cryptog. Phytopathol.* 5: 165 [*Gen. Fil.*] (1947). E, E
Scolopendrium schizocarpum Copel., *Philipp. J. Sci.* 1(Suppl. 2): 152, t. 9 (1906); *Phyllitis schizocarpa* (Copel.) Alderw., *Bull. Dépt. Agric. Indes Néerl.* 21: 6 (1908); *Diplora schizocarpa* (Copel.) C.Chr., *Index Filic. Suppl. Tert.* 78 (1934)
Type: PHILIPPINES (Mindanao), *Copeland 1743*, holotype: MICH [1190974*]; isotypes: NY [00128037*], P [00642941*] [00642942*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11610*, BSIP!, TNM!

Asplenium scolopendropsis F.Muell., *Pap. Plants* 3: 49 (1876). E, I
Phyllitis scolopendropsis (F.Muell.) Alderw., *Bull. Dépt. Agric. Indes Néerl.* 21: 6 (1908)
Type: PAPUA NEW GUINEA, *D'Albertis s.n.*, holotype: MEL [295766*].
Voucher: Tetepare, 0–200 m, 24 Aug 2013, *Chen et al. SITW03355*, BSIP!, TAIF [448694!], TNM!
Note: The new name *Asplenium insulanum* C.W.Chen provided by Chen et al. (2017a) is unnecessary and should be considered a synonym of *A. scolopendropsis* based on ICN Art. 11.4.

Asplenium tenerum G.Forst., *Fl. Ins. Austr.* 80 (1786). E, T
Darea tenera (G.Forst.) Spreng., *J. Bot. (Schrader)* 1799(2): 269 (1799)
Type: PACIFIC ISLANDS, *Forster s.n.*, lectotype: UPS-THUNB [24851*], designated by Veldkamp and Wardani (2015).
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11582*, BSIP!, TNM!

Asplenium translucens (Holttum) Viane, *Biol. Jaarb.* 59: 163 (1991). E, B
Diplora translucens Holttum, *Dansk Bot. Ark.* 25: 41 (1967)
Type: PAPUA NEW GUINEA (Bismarck Archipelago), *Koie 1824*, holotype: K [001092598*].
Voucher: Tetepare, 200–300 m, 23 Jun 2013, *Hu et al. SITW02855*, BSIP!, TAIF [445800!], TNM!

***Asplenium* sp.** E
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10585*, BSIP!, TAIF [520541!], TNM!
Note: This species was identified as *A. australasicum* (J.Sm.) Hook. in Chen et al. (2017a). Bird-nest *Asplenium* with acutely keeled abaxial midribs throughout the Pacific and eastern Australia have been included within *A. australasicum* (Sasaki, 2008). However, phylogenetic analyses of chloroplast DNA sequences (Ohlsen et al., 2014a, Xu et al., 2020) have shown that some populations in the Pacific traditionally included in *A. australasicum* are more closely related to other bird-nest *Asplenium* species than they are to the true *A. australasicum* from Australia. Preliminary analysis of a Solomon Islands sample (WELT P028303) has revealed that it is more closely related to other species than to true *A. australasicum*. Consequently, this species in the Solomon Islands remains unidentified until a thorough revision of bird-nest *Asplenium* is conducted, and a name can be applied.

HYMENASPLENIUM Hayata, *Bot. Mag. (Tokyo)* 41(492): 712 (1927)
Hymenasplenium excisum (C.Presl) S.Linds., *Thai Forest Bull., Bot.* 37: 69 (2009). T, S
Asplenium excisum C.Presl, *Epimel. Bot.* 74 (1851 [‘1849’])
Type: PHILIPPINES (Luzon), *Cuming 110*, lectotype: PRC [450240*], designated by Field (2020); isolectotypes: BM [001045248*] [001045250*], E [00210754*], K [000446740*], [000446741*], MICH [1191186*], P [00642978*] [00642979*], US [00065601*].
Voucher: Guadalcanal, 860 m, 22 Jan 1992, *Glenny 3517*, BSIP!, WELT [P017431!].

Hymenasplenium perriei Li Bing Zhang & K.W.Xu, *Phytotaxa* 356(2): 177 (2018). T, O
Type: FIJI (Viti Levu), *Perrie et al. Fiji 2011 13*, holotype: WELT [P023745!]; isotype: SUVA!
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11149*, BSIP!, TNM!
Note: This species was included in *H. unilaterale* (Lam.) Hayata and illustrated under that name in Chen et al. (2017a). To address the morphological and genetic variability within a broadly defined *H. unilaterale*, Xu et al. (2018a, 2018b, 2019) proposed a finely divided classification and described many new species including *H. solomonense* Li Bing Zhang & K.W.Xu from the Solomon Islands. However, most of their new species were

based on very few specimens and the morphological support for their classification is weak. Therefore, we here follow Ohlsen (2020c), who adopted the name *H. perriei* for the Solomon Islands.

BLECHNACEAE Newman, *Hist. Brit. Ferns*, ed. 2, 8 (1844)
Here we adopt a system of seven genera proposed by Perrie et al. (2014) including a broadly circumscribed *Blechnum* that eliminates some segregates of Gasper et al. (2016) that are difficult to recognise morphologically.

BLECHNUM L., *Sp. Pl.* 2: 1077 (1753)
Blechnum megavulcanicum T.C.Chambers, *Telopea* 22: 54 (2019). T, D
Cranfillia megavulcanica (T.C.Chambers) Parris & de Lange, *Telopea* 22: 155 (2019)
Type: SOLOMON ISLANDS (Santa Isabel), *Whitmore BSIP 2393*, holotype: K [000754243]; isotypes: BSIP!, L [3516913].
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05399*, BSIP!, TAIF [471802!] [471863!], TNM!
Note: This species belongs to the *Blechnum vulcanicum* group and was identified as *B. vulcanicum* (Blume) Kunh in Chen et al. (2017a). Here we follow the study of Chambers & Wilson (2019) that recognised a total of 13 species in this group and described the populations in the Solomon Islands as a new species. Morphologically, it differs from *B. vulcanicum s.s.* by having larger fronds (usually over 70 cm long) with up to 29 pairs of segments. Another species identified as *Blechnum* sp. in Chen et al. (2017a) was also included here because its distinguishing characters fall within the variation of *B. megavulcanicum*.

Blechnum melanocaulon (Brack.) T.C.Chambers & P.A.Farrant subsp. ***pallens*** T.C.Chambers & P.A.Farrant, *Blumea* 46(2): 321 (2001). T, N
Lomaria elongata Blume, *Enum. Pl. Javae* 2: 201 (1828); *Austroblechnum melanocaulon* (Brack.) Gasper & V.A.O.Dittrich subsp. *pallens* (T.C.Chambers & P.A.Farrant) Parris, *Fl. Pen. Malaysia* 1, 3: 213 (2020)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L [3520830*], designated here by Chen; isolectotypes: L [3520806*] [3520812*] [3520820*] [3520831*] [3520832*] [3520833*] [3520836*] [3520837*] [3520838*].
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05399*, BSIP!, TAIF [473016!] [473017!], TNM!
Note: The designated lectotype has both fertile and sterile material and shows the pale axes characteristic of the subspecies. It is also annotated with the locality "Kandang Badak" mentioned by Chambers & Farrant (2001), whose type statement did not fulfil Article 7.11.

Blechnum nesophilum T.C.Chambers & P.A.Farrant, *Blumea* 46(2): 322 (2001). T, D
Parablechnum nesophilum (T.C.Chambers & P.A.Farrant) Gasper & Salino, *Phytotaxa* 275(3): 216 (2016)
Type: PAPUA NEW GUINEA (Admiralty Is.), *Croft 1224*, holotype: CANB [CBG8904708*]; isotype: NSW.
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10582*, BSIP!, TAIF [520044!] [520045!] [520046!] [520047!] [520048!] [520049!], TNM!

Blechnum orientale L., *Sp. Pl.*, 1077 (1753). T, S
Blechnopsis orientalis (L.) C.Presl, *Epimel. Bot.* 117 (1851 ['1849'])
Type: CHINA, *Hou et al. 015043*, neotype: PE [01601925*], designated by Mazumdar (2016a).
Voucher: Malaita, 150–350 m, 22 Jul 2015, *Chen et al. SITW07645*, BSIP!, TAIF [486633!], TNM!

Blechnum phanerophlebium C.Chr., *Bull. Misc. Inform. Kew* 1939(1): 28 (1939). T, C
Cranfillia phanerophlebia (C.Chr.) de Lange & Parris, *Telopea* 22: 155 (2019)
Type: FIJI (Viti Levu), *Horne 939*, holotype: K [000721923*].
Voucher: Guadalcanal, *Brown 2452*, BM [000801687].
Note: We provisionally recognise this species based on Chambers & Wilson (2019).

Blechnum vittatum Brack., *U.S. Expl. Exped., Filic.* 16: 131, t.16 (1854). T, D
Blechnum cartilagineum var. *vittatum* (Brack.) Luerss., *Fil. Graeff.* 132 (1871); *Oceaniopteris vittata* (Brack.) Gasper & Salino, *Phytotaxa* 275(3): 215 (2016)
Type: FIJI, *Wilkes Explor. Exped. 8*, holotype: US [00135474*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10437*, BSIP!, TAIF [519467!], TNM!

STENOCHLAENA J.Sm., *J. Bot.* 3: 401 (1841)
Stenochlaena milnei Underw., *Bull. Torrey Bot. Club* 33: 38 (1906). C, E
Type: SOLOMON ISLANDS, *Milne 518*, holotype: K [001092782*]; isotypes: BM [001048333*], NY [00128347*].
Voucher: Malaita, 150–350 m, 22 Jul 2015, *Chen et al. SITW07666*, BSIP!, TAIF [486565!] [486566!] [486567!], TNM!

Stenochlaena palustris (Burm.f.) Bedd., *Suppl. Ferns S. Ind.* 26 (1876), as '*palustre*'
Polypodium palustre Burm.f., *Fl. Indica* 234 (1768) C, S
Type: INDONESIA (Java), *s.c., s.n.*, lectotype: G-PREL, designated by Mazumdar et al. (2019).
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10477*, BSIP!, TAIF [519907!] [519909!], TNM!

ATHYRIACEAE Alston, *Taxon* 5: 25 (1956)
DEPARIA Hook. & Grev., *Icon. Filic.* 2(8): t.154 (1830)
Deparia petersenii subsp. ***congrua*** (Brack.) M.Kato, *J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot.* 13: 426 (1984). T, J
Diplazium congruum Brack., *U.S. Expl. Exped., Filic.* 141, t. 18 (1854)
Type: SAMOA, *Wilkes Explor. Exped. 4*, holotype: US [00135221*].
Voucher: Guadalcanal, 600–1300 m, 23 Jun 2016, *Chen et al. SITW11609*, BSIP!, TAIF [498926!], TNM!
Note: *Deparia petersenii* is cytologically variable (e.g., Shinohara et al., 2006). A chromosome count based on *Chen et al. SITW11609* shows that it is tetraploid ($2n = 160$, counted by C.-W. Chen).

DIPLAZIUM Sw., *J. Bot. (Schrader)* 1800(2): 4, 61 (1801)
Diplazium bamlerianum Rosenst., *Repert. Spec. Nov. Regni Veg.* 10: 329 (1912). T, B

Type: PAPUA NEW GUINEA (Sattelberg), *Bamler 40* = *Keysser 40*, lectotype: BM [000822565*], designated here by Chen; isolectotypes: BM [000822567*], MICH [1190350*], NY [04064326*], UC [352698*].
Voucher: Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11640*, BSIP!, TAIF [498917!], TNM!
Note: This species has sometimes been treated as a synonym of *D. weinlandii* Christ (Copeland, 1949b) and in Chen et al. (2017a). After examining the types of both names, we thought they might be two different species, with the Solomon Islands plants a better match with type material of *D. bamlerianum*. Several original specimens with Rosenstock's annotation are known, and we selected the most complete one containing a mature plant with rhizome and a few juvenile plants as the lectotype.

Diplazium bantamense Blume, *Enum. Pl. Javae* 2: 191 (1828). T, L
Asplenium bantamense (Blume) Baker, *Syn. Fil.* 231 (1868); *Athyrium bantamense* (Blume) Milde, *Bot. Zeitung (Berlin)* 28: 353 (1870)
Type: INDONESIA (Java), *Hasselt s.n.*, holotype: L [0051547*].
Voucher: Guadalcanal, 400–1000 m, 30 Jun 2014, *Chen et al. SITW05292*, BSIP!, TAIF [464785!], TNM!
Note: This species was identified as *D. oblongifolium* (Hook.) Jermy in Chen et al. (2017a). Our unpublished data show that the specimens with (*Chen et al. SITW05292*) or without bulbils on pinnae bases (*Chen et al. SITW11600*) have almost identical DNA sequences and should be recognised as one species. We tentatively adopt the name *D. bantamense* because it is earlier, but further study is needed to clarify the relationship of these two taxa.

Diplazium cominsii (Baker) C.Chr., *Index Filic.* 230 (1905). T, A
Gymnogramma cominsii Baker, *J. Linn. Soc., Bot.* 19: 296 (1882)
Type: SOLOMON ISLANDS (Makira), *Comins 41*, holotype: K [000826204*]; isotype: WELT [P014703!].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11586*, BSIP!, TAIF [498935!] [498936!] [498937!] [498938!] [498939!], TNM!
Note: Endemic. This species was misidentified as *D. harpeodes* T.Moore in Chen et al. (2017a). Both morphological and genetic variation (unpubl. data) suggested that the current circumscription needs further study.

Diplazium cordifolium Blume, *Enum. Pl. Javae* 2: 190 (1828). T, M
Type: INDONESIA (Java), *Hasselt s.n.*, lectotype: L [0051534*], designated by Hovenkamp (2019); isolectotypes: L [0063139*] [0063140*].
Voucher: Makira, 910 m, 1 Jul 2015, *Chen et al. SITW06826*, BSIP!, TAIF [482771!], TNM!, VT!

Diplazium cristovalense (Baker) C.W.Chen, *comb. et stat. nov.* T, A
Asplenium umbrosum var. *cristovalense* Baker, *J. Linn. Soc., Bot.* 19: 294 (1882)
Type: SOLOMON ISLANDS (Makira), *Comins 40*, holotype: K [000853317*].
Note: Endemic and known only by its holotype of an incomplete frond. Baker (1882) suggested a close affinity with *Diplazium assimile* (Endl.) Bedd.

Diplazium cultratum C.Presl, *Epimel. Bot.* 84 (1851 ['1849']). T, E

Type: PHILIPPINES (Luzon), *Cuming 199*, lectotype: PRC [450327*], designated by Holttum (1968b); isolectotypes: B [20 0047231*], K [000516144*], L [0537126*].
Voucher: Guadalcanal, 600–1300 m, 23 Jun 2016, *Chen et al. SITW11598*, BSIP!, TAIF [498931!] [498932!], TNM!
Note: This specimen was unidentified by Chen et al. (2017a: 331), so the taxon is newly recorded from the Solomon Islands. The Solomon Islands plants differ from the type material in having larger fronds and nearly entire pinna margins (vs. dentate). Further study is needed to confirm whether populations from the Philippines and the Solomon Islands are conspecific. We disagree with Hovenkamp (2019) who synonymised *D. cultratum* under *D. phanerotis* Kunze.

Diplazium cumingii (C.Presl) C.Chr., *Index Filic*. 230 (1905). T, E
Ochlogramma cumingii C.Presl, *Epimel. Bot*. 94 (1851 ['1849']); *Athyrium cumingii* (C.Presl) Milde, *Bot. Zeitung (Berlin)* 28: 353 (1870)
Type: Philippines (Luzon), *Cuming 116*, holotype: PRC, not found by Holttum (1968c); isotypes: B [20 0047234*], BM [000905167*] [000905168*] [000905169*], K [000507513*] [000507514*] [000507515*] [000507516*] [000507517*] [000507518*], L [0537135*] [0537136*], MICH [1191375*], US [01100868*].
Voucher: Kolombangara, 762 m [2500 ft], 3 Sep 1965, *Braithwaite RSS 4440*, BSIP!, L [3540057*].

Diplazium dameriae Pic.Serm., *Webbia* 45(2): 357 (1991). T, K
Type: AUSTRALIA (Queensland), *Oraino & Dameri s.n.*, holotype: FI [004119*], isotypes: BRI-AQ [0560022], FI [004120*].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10529*, BSIP!, TAIF [520619!] [520620!], TNM!

Diplazium dilatatum Blume, *Enum. Pl. Javae* 2: 194 (1828). T, S
Type: INDONESIA (Java), *Blume s.n.*, holotype: L [0051552*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11605*, BSIP!, TAIF [498927!] [498928!], TNM!

Diplazium esculentum (Retz.) Sw., *J. Bot. (Schrader)* 1801(2): 312 (1803). T, T
Hemionitis esculenta Retz., *Observ. Bot*. 6: 38 (1791)
Type: INDIA, *Konig s.n.*, lectotype: LD [1122195*], designated by Fischer (1932); isolectotype: K [001089389*].
Voucher: Guadalcanal, 100–500 m, 27 Jul 2014, *Chen et al. SITW05733*, BSIP!, TAIF [472147!], TNM!

Diplazium geophilum (Copel.) Alderw., *Bull. Jard. Bot. Buitenzorg*, ser. 2, 7: 12 (1912). T, H
Athyrium geophilum Copel., *Philipp. J. Sci., C.* 3: 296 (1908)
Type: PHILIPPINES (Negros), *Elmer 9884*, holotype: MICH [1287005*].
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04917*, BSIP!, TAIF [463839!], TNM!
Note: Chen et al. (2017a) identified this species as *D. squamuligerum* (Rosenst.) Parris, but here we follow Christensen (1934), who recognised it as a synonym of *D. geophilum*.

Diplazium murkele Hovenkamp, *Fern Gaz.* 20(2): 52 (2015). T, E
Type: INDONESIA (Maluku, Seram), *Kato et al. C 1292*, holotype L [3543808*]; isotypes: TI, BO.
Voucher: Kohinggo, 5 m, 17 May 2013, *Chang et al. SITW02435*, BSIP!, TAIF [443194!], TNM!
Note: Newly recorded from the Solomon Islands.

Diplazium pallidum (Blume) T.Moore, *Index Fil.* 16: 333 (1861). T, E
Asplenium pallidum Blume, *Enum. Pl. Javae* 2: 177 (1828)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L [0051559*], designated here by Chen; isolectotype: L [0051560*].
Voucher: Guadalcanal, 800–1000 m, 16 Sep 2015, *Hsu et al. SITW09649*, BSIP, TNM!
Note: There are two specimens in L with the name *Diplazium pallidum* in Blume's hand, and both are from the location given in the protologue ("montis Burangrang"). We selected the sheet with more developed fronds as lectotype.

Diplazium polypodioides Blume, *Enum. Pl. Javae* 2: 194 (1828). T, P
Athyrium polypodioides (Blume) Milde, *Bot. Zeitung (Berlin)* 28: 354 (1870) *nom. illeg. non* Schur, *Oesterr. Bot. Z.* 8: 194 (1858)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L [0051563*], designated by Hovenkamp (2019).
Voucher: Guadalcanal, 400–800 m, 17 Jun 2016, *Chen et al. SITW11187*, BSIP!, TAIF [498941!] [498942!], TNM!
Note: This species was misidentified as *D. cominsii* in Chen et al. (2017a).

Diplazium proliferum (Lam.) Kaulf., *Enum. Filic.* 182 (1824). T, T
Asplenium proliferum Lam., *Encycl.* 2(1): 307 (1786); *Callipteris prolifera* (Lam.) Bory, *Voy. Îles Afrique* 283 (1804).
Type: RÉUNION, *Commerson s.n.*, lectotype: P [00564927*], designated by Hovenkamp (2019); isolectotypes: B [20 0049248*], MPU [018120*] [018121*], P [00564928*].
Voucher: Kolombangara, 600–700 m, 5 Aug 2013, *Chen et al. SITW02994*, BSIP!, TAIF [444964!] [444965!] [444966!], TNM!
Note: A specimen with deeply divided pinnae (*Chen et al. SITW07719*) may be a hybrid between *D. proliferum* and *D. stipitipinnula* Holttum.

Diplazium schlechteri Hieron., *Bot. Jahrb. Syst.* 56(1): 138 (1920). T, B
Type: PAPUA NEW GUINEA, *Schlechter 14339*, lectotype: B [20 0049491*], designated here by Chen.
Voucher: Vanikoro, 420–780 m, 18 Jun 2016, *Chen et al. SITW11020*, BSIP!, TAIF [498877!] [498878!], TNM!
Note: Several syntypes were cited in the protologue; we selected the only known syntype collected by Rudolf Schlechter as lectotype.

Diplazium stipitipinnula Holttum, *Blumea* 14: 328 (1967). T, B
Type: PAPUA NEW GUINEA, *Hoogland 9090*, holotype: K [000548336*]; isotypes: CANB [143017*] [143018*] [143019*], L [0051574*] [0051575*] [0051576*].
Voucher: Kolombangara, 150–350 m, 22 Jul 2015, Chen et al. *SITW07634,* BSIP!, TAIF [486585!], TNM!, VT!

***Diplazium* sp.** T
Voucher: Guadalcanal, 1300–1750 m, 11 Sep 2015, *Hung et al. SITW09785*, BSIP!, TAIF [516201!], TNM!
Note: This voucher remains unidentified after comparison with congeneric species from neighbouring countries. It is characterised by its long-elliptic fronds, 1-pinnate-pinnatifid laminae, free veins, and concolourous scales with entire margins. It might represent an undescribed species.

THELYPTERIDACEAE Pic.Serm., *Webbia* 24(2): 709 (1970)
Based on morphological study and a 600-taxon nuclear DNA phylogenomic analysis (Fawcett et al., 2021a), Fawcett & Smith (2021) proposed a revised generic taxonomy of the Thelypteridaceae including a major re-circumscription of genera. The circumscription of species treated in Chen et al. (2017a) remains unchanged for the genera *Christella, Coryphopteris*, and *Macrothelypteris*, while the remaining six genera are impacted to varying degrees. The single species of *Amblovenatum* was determined to be distantly related to the type of that genus and was transferred to *Mesopteris*. *Chingia* was expanded to include a newly recognised species, *Chingia tortuosa* (Fawcett et al., 2021b), treated by Chen et al. (2017a) as *Pneumatopteris* sp. 1. *Plesioneuron* was expanded by including *Pneumatopteris imbricatum* within it. *Pneumatopteris* was highly polyphyletic as circumscribed by Holttum (1971, 1973, 1977, 1982); as defined by Fawcett & Smith (2021), only *P. glandulifera* remains in the Solomon Islands flora, with most other taxa transferred to a newly described genus *Reholttumia*. *Pronephrium* also proved to be non-monophyletic, although clades corresponded somewhat to Holttum's infrageneric classification (Holttum, 1972; 1982). Species in the Solomon Islands recognised by Chen et al. (2017a) were transferred to *Sphaerostephanos* and to *Grypothrix*, a section of *Pronephrium* recognised by Holttum (1982) but elevated to generic rank by Fawcett & Smith (2021). Two species of *Sphaerostephanos* were found to be distantly related to most members of the genus and were treated together in a new genus, *Strophocaulon* (Fawcett & Smith, 2021).

CHINGIA Holttum, *Blumea* 19: 31 (1971)
Chingia longissima (Brack.) Holttum, *Kalikasan* 3: 17 (1974). T, F
Goniopteris longissima Brack., *U.S. Expl. Exped., Filic.* 16: 29, f. 5 (1854); *Polypodium longissimum* (Brack.) Hook., *Sp. Fil.* 5: 7 (1863), *non* Blume, *Enum. Pl. Javae* 2: 127 (1828); *Nephrodium longissimum* (Brack.) Diels, *Nat. Pflanzenfam.* 1(4): 179 (1899); *Dryopteris longissima* (Brack.) C.Chr., *Index Filic.* 276 (1905); *Phegopteris longissima* (Brack.) Alderw., *Mal. Ferns Suppl.* 318 (1917); *Cyclosorus longissimus* (Brack.) Ching, *Bull. Fan Mem. Inst. Biol.* 10: 246 (1941); *Thelypteris longissima* (Brack.) C.F.Reed, *Phytologia* 17: 290 (1968)
Type: FRENCH POLYNESIA (Tahiti), *Wilkes Explor. Exped. 5*, holotype: US [00134984*]; isotype: K [000951464*].
Voucher: Kolombangara, 600–700 m, 5 Nov 2013, *Chen et al. SITW04074*, BSIP!, TAIF [459999!], TNM!
Note: A broad taxonomic concept has been applied to *Chingia longissima*. The Solomon Islands specimen (based on *Chen et al. SITW2971 = Chen Wade 2725*) is not sister to that from Polynesia in the phylogeny of Fawcett et al. (2021a). Recent work by Game et al. (2018) revealed greater diversity and endemism than previously recognised, and the

genus is in need of additional study.
Chingia malodora (Copel.) Holttum, *Kalikasan* 3: 19 (1974). T, A
Dryopteris malodora Copel., *Philipp. J. Sci.* 60: 108, t. 13 (1936); *Cyclosorus malodorus* (Copel.) Copel., *Ann. Cryptog. Phytopathol.* 5: 143 [*Gen. Fil.*] (1947); *Thelypteris malodora* (Copel.) C.F.Reed, *Phytologia* 17: 291 (1968)
Type: SOLOMON ISLANDS (Makira), *Brass 2688*, lectotype: MICH [1003435A*] [1003435B*], designated by Holttum (1974b); isolectotypes: P [00645285*], US [00048653*], K [000951463*], BRI [AQ0024512*, three sheets].
Voucher: Guadalcanal, 50–300 m, 13 Jul 2016, *Chen et al. SITW11121*, BSIP!, TNM!
Note: Endemic. Based on the phylogeny of Fawcett et al. (2021a), *Chingia malodora* (based on *Chen et al. SITW11121*) is sister to a clade that includes *C. fijiensis, C. marattioides*, and both accessions of *C. longissima*.

Chingia tortuosa S.E.Fawc., C.W.Chen & A.R.Sm., *Blumea* 66: 223 (2021). T, A
Type: SOLOMON ISLANDS (Vanikoro), 600 m, 27 Jun 2016, *Chen et al. SITW11087*, holotype: BSIP!; isotypes: TAIF [498969!] [498970!] [498971!] [498972!], TNM!, UC [2048647!].
Note: Endemic. Treated as *Pneumatopteris* sp. 1 by Chen et al. (2017a: 356–357). In the phylogeny of Fawcett et al. (2021a), *C. tortuosa* (based on *Chen et al. SITW11087*) was most closely related to an individual of *C. clavipilosa* from Mount Kinabalu, Borneo.

CHRISTELLA H.Lév., *Fl. Kouy-Tcheou* 472 (1915)
Christella dentata (Forssk.) Brownsey & Jermy, *Brit. Fern Gaz.* 10: 338 (1973). T, T
Polypodium dentatum Forssk., *Fl. Aegypt.-Arab.* 185 (1775); *Dryopteris dentata* (Forssk.) C.Chr., *Kongel. Danske Vidensk. Selsk. Skr., Naturvidensk. Math. Afd.* 8(6): 24 (1920); *Nephrodium dentatum* (Forssk.) Kümmerle, *Mag. Bot. Lapok* 32: 60 (1933); *Thelypteris dentata* (Forssk.) E.P.St.John, *Amer. Fern J.* 26(2): 44 (1936); *Cyclosorus dentatus* (Forssk.) Ching, *Bull. Fan Mem. Inst. Biol.* 8: 206 (1938)
Type: YEMEN, *Forsskal 809*, holotype: C [10002814*].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10525*, BSIP!, TAIF [520548!] [520549!] [520551!], TNM!

Christella harveyi (Mett. ex Kuhn) Holttum var. ***harveyi***, *Kew Bull.* 31: 306 (1976). T, D
Aspidium harveyi Mett. ex Kuhn, *Linnaea* 36(1): 115 (1869); *Lastrea harveyi* (Mett. ex Kuhn) Carruth., *Fl. Vit.* 359 (1873); *Nephrodium harveyi* (Mett. ex Kuhn) Baker, *Syn. Fil.*, ed. 2, 497 (1874); *Dryopteris harveyi* (Mett. ex Kuhn) Kuntze, *Revis. Gen. Pl.* 2: 812 (1891); *Thelypteris harveyi* (Mett. ex Kuhn) Proctor ex K.Iwats., *Amer. Fern J.* 53: 133 (1963); *Cyclosorus harveyi* (Mett. ex Kuhn) Mazumdar & R.Mukhop., *J. Bot. Soc. Bengal* 67(1): 45 (2013)
Type: FIJI, *Harvey s.n.*, lectotype: B [20 0057717*], designated by Holttum (1976); isolectotype: K [000889897*].
Voucher: Guadalcanal, 50–150 m, 11 Jul 2016, *Chen et al. SITW11097*, BSIP!, TNM!
Note: In the protologue, Mettenius cited two syntypes, one from Fiji and one from New Hebrides. Holttum (1976) considered that the Fijian type at B, and an isotype at K, both of which constituted several sheets, might represent original material; however only the collection from 1855 was in both herbaria and was annotated by Holttum at K. Unfortunately, the type at Berlin includes five fragments that likely represent more than

one individual. A specimen from Fiji was included in the phylogeny of Fawcett et al. (2021a) and resolved in a clade with *C. gretheri* and *C. perpubescens* that is sister to the rest of *Christella*.

Christella harveyi (Mett. ex Kuhn) Holttum var. ***connivens*** Holttum; *Kew Bull.* 31(2): 307 (1976). T, A
Cyclosorus connivens (Holttum) Mazumdar & Mukhop., *J. Bot. Soc. Bengal* 67(1): 45 (2013)
Type: SOLOMON ISLANDS (Guadalcanal), *Braithwaite RSS 4638*, holotype: K; isotypes: BSIP, L [0931043*], CANB [373912*].
Note: Endemic and known only from the type collection.

Christella parasitica (L.) H.Lév., *Fl. Kouy-Tcheou* 473, 475 (1915). T, T
Polypodium parasiticum L., *Sp. Pl.* 2: 1090 (1753); *Aspidium parasiticum* (L.) Sw., *J. Bot. (Schrader)* 1800(2): 35 (1801); *Dryopteris parasitica* (L.) Kuntze, *Revis. Gen. Pl.* 2: 811 (1891); *Cyclosorus parasiticus* (L.) Farw., *Amer. Midl. Naturalist* 12: 259 (1931); *Thelypteris parasitica* (L.) Tardieu, *Notul. Syst.* 7: 75 (1938)
Type: CHINA (Canton), *Osbeck s.n.*, lectotype: S-P [2653*], designated by Holttum (1974b).
Voucher: Guadalcanal, 150–400 m, 6 Sep 2012, *Chen et al. SITW00415*, BSIP!, TAIF [417244!], TNM!
Note: A decision on the proposal of Fraser-Jenkins et al. (2018b) that conserves the name *Polypodium parasiticum* with a type that would maintain prevailing usage is pending.

Christella perpubescens (Alston) Holttum, *Kew Bull.* 31(2): 304 (1976). T, B
Dryopteris perpubescens Alston, *J. Bot.* 78: 227 (1940); *Lastrea perpubescens* (Alston) Copel., *Philipp. J. Sci.* 78: 424 (1951); *Thelypteris perpubescens* (Alston) C.F.Reed, *Phytologia* 17: 303 (1968); *Cyclosorus perpubescens* (Alston) Mazumdar & R.Mukhop., *J. Bot. Soc. Bengal* 67(1): 46 (2013)
Type: PAPUA NEW GUINEA (Morobe), *Clemens 7902C,* holotype: B [20 0125006*]; isotypes: B [B 20 0063157*], BM [BM001045119*], L [L0931042*], U [U0007559*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11156*, BSIP!, TNM!, UC [2048637!].
Note: Based on his study of *Braithwaite RSS 4841*, Holttum (1977) provisionally identified this collection as the New Guinean species *C. perpubescens* (Alston) Holttum but noted its more deeply lobed pinnae and lack of capitate hairs. Glenny later described *C. calcarea* as a distinct species based on *Braithwaite RSS 4841* in his unpublished manuscript of ferns of the Solomon Islands. However, examination of more recently collected material from the Solomon Islands (*Chen et al. SITW11156*) revealed the presence of capitate hairs, these most abundant on the proximal portion of the stipe. We follow Holttum (1977) in recognising the Solomon Island plants as *C. perpubescens*, pending further study. This species belongs to a small group of rare, low elevation calciphiles treated as *Christella* sect. *Leptochristella* by Holttum (1982). Additional species include *C. buwaldae* (Holttum) Holttum, *C. minima* Holttum, and *C. nana* Holttum, each known only from the type or from the type and one additional collection. Based on the phylogeny of Fawcett et al. (2021a), which did not include other members of *Christella* sect. *Leptochristella*, *C. perpubecens* (based on *Chen et al. SITW11156*, treated as *C. calcarea* D.Glenny, *ined.*) forms a clade with two other Pacific Island

species, *C. gretheri* (W.H.Wagner) Holttum and *C. harveyi*; together, these three are sister to the remaining species of the largely East Asian *Christella s.s.* clade.

CORYPHOPTERIS Holttum, *Blumea* 19: 33 (1971)
Coryphopteris kolombangarae Holttum, *Blumea* 23(1): 36 (1976). T, A
Type: SOLOMON ISLANDS (Kolombangara), *Braithwaite RSS 4377*, holotype: K [000951501*]; isotypes: P [00633654*], L [0052337*], CANB [378018*], GH [00020776*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07554*, BSIP!, TAIF [486651!], TNM!
Note: Endemic. In the phylogeny of Fawcett et al. (2021a) this taxon (*Chen et al. SITW4908 = Chen Wade 3367*) is sister to *C. fasciculata* (E.Fourn.) Holttum.

Coryphopteris pubirachis (Baker) Holttum var. ***major*** Holttum; *Blumea* 23: 37 (1976). T, B
Type: SOLOMON ISLANDS (Kolombangara), *Braithwaite RSS 4378*, holotype: K [000951500*] [000951499*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW06954*, BSIP!, TAIF [482812!], TNM!, VT [284048!].
Note: A Philippine accession of *C. pubirachis* in the phylogeny of Fawcett et al. (2021a) resolves as sister to *C. obtusata* (Alderw.) Holttum.

Coryphopteris subbipinnata Holttum; *Blumea* 23(1): 33 (1976). T, A
Type: SOLOMON ISLANDS (Guadalcanal), *Braithwaite RSS 4757*, holotype: K [000951493*] [000951494*] [000951495*]; isotypes: P [00633655*], L [0057438*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11667*, BSIP!, TAIF [498911!] [498912!], TNM!
Note: Endemic. *Braithwaite RSS 4757* in K comprises three sheets, and they are clearly labelled as being part of a single specimen; in accordance with ICN Art. 8.3 (Turland et al., 2018), they are considered parts of the holotype. In the phylogenetic study of Fawcett et al. (2021a), this species (*Chen et al. SITW4889 = Chen Wade 3348*) resolves in a clade that includes the Fijian endemic *C. seemannii* Holttum.

CYCLOSORUS Link, *Hort. Berol.* 2: 128 (1833)
Cyclosorus interruptus (Willd.) H.Itô, *Bot. Mag.* 51: 714, f.9 (1937). A, T
Pteris interrupta Willd., *Phytographia* 13, t.10, f.1 (1794); *Dryopteris interrupta* (Willd.) Ching, *Lingnan Sci. J.* 12: 566 (1933); *Thelypteris interrupta* (Willd.) K.Iwats., *J. Jap. Bot.* 38: 314 (1963)
Type: INDIA, lectotype: Willdenow, *Phytographia* t. 10, f. 1 (1794), designated by Mazumdar (2016b); *Klein s.n.*, epitype: B-W [19770011*], designated by Mazumdar (2016b); isoepitypes: B-W [19770012*], BM [000542220*].
Voucher: Tulagi, 8 Jul 1936, *Lever s.n.*, BRI-AQ [175101*].
Note: Klein's specimen in Herb. Willdenow has been considered as the type, e.g., by Holttum (1973). However, Mazumdar (2016b) has shown that this specimen is not original material, rather a later collection.

GRYPOTHRIX (Holttum) S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 46 (2021)
***Grypothrix* sp.** T, L

Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05645*, BSIP!, TAIF [472917!], TNM!
Note: The only *Grypothrix* from the Solomon Islands recognised in earlier treatments (e.g., Holttum 1977) is the widespread *G. cuspidata* (Blume) S.E. Fawc. & A.R. Sm., which is typified by a collection from Java. In the phylogeny of Fawcett et al. (2021a), *Chen et al. SITW05645* (= *Chen Wade 4074*) is most closely related to two accessions of *G. ramosii* (Christ) S.E. Fawc. & A.R. Sm., from the Philippines and West Papua. We have determined that the plants occurring in the Solomon Islands represent an undescribed species to be published separately.

MACROTHELYPTERIS (H.Ito) Ching, *Acta Phytotax. Sin.* 8(4): 308 (1963)
Macrothelypteris polypodioides (Hook.) Holttum, *Blumea* 17: 29 (1969). T, S
Alsophila polypodioides Hook., *Oceanic Sketches* 131 (1835)
Type: FRENCH POLYNESIA, *Nightingale s.n.*, lectotype: K [000880396*] [000880397*], designated by Holttum (1969).
Voucher: Guadalcanal, 50–30 m, 13 Jul 2016, *Chen et al. SITW11122*, BSIP!, TNM!

Macrothelypteris torresiana (Gaudich.) Ching, *Acta Phytotax. Sin.* 8: 310 (1963). T, T
Polystichum torresianum Gaudich., *Voy. Uranie* 8: 333 (1828); *Lastrea torresiana* (Gaudich.) T.Moore, *Index Fil.* 5: 106 (1858); *Thelypteris torresiana* (Gaudich.) Alston, *Lilloa* 30: 111 (1960)
Type: MARIANA ISLANDS, *Gaudichaud s.n.*, lectotype: P, designated by Holttum (1969); isolectotype: G [00348963].
Voucher: Vanikoro, 100–370 m, 24 Jun 2016, *Chen et al. SITW11071*, BSIP!, TNM!

MESOPTERIS Ching, *Acta Phytotax. Sin.* 16(4): 21 (1978)
Mesopteris pseudostenobasis (Copel.) S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 58 (2021). T, E
Dryopteris pseudostenobasis Copel., *J. Arnold Arbor.* 10: 176 (1929); *Cyclosorus pseudostenobasis* (Copel.) Ching, *Bull. Fan Mem. Inst. Biol.* 10: 248 (1941); *Thelypteris pseudostenobasis* (Copel.) C.F.Reed, *Phytologia* 17: 306 (1968); *Amphineuron pseudostenobasis* (Copel.) Holttum, *Fl. Males., ser. 2, Pterid.* 1(5): 549 (1981); *Amblovenatum pseudostenobasis* (Copel.) C.W.Chen, *Sol Amazing* 335 (2017)
Type: PAPUA NEW GUINEA, *Brass 1000*, lectotype: UC [377986*], designated by Holttum (1977); isolectotypes: BM [001045101*], BRI [AQ0024900*], GH [00046944*], MICH [1003439A*] [1003439B*].
Voucher: Guadalcanal, 50–150 m, 11 Jul 2016, *Chen et al. SITW11106*, BSIP!, TNM!
Note: This species was placed in *Amblovenatum* in Chen et al. (2017a), but here we follow Fawcett et al. (2021a) who found that this taxon (based on *Chen et al. SITW3789* = *Chen Wade 3208*) is more closely related to the type species of *Mesopteris* than to the type of *Amblovenatum* (synonym: *Amphineuron* Holttum, *nom. illeg.*).

PLESIONEURON (Holttum) Holttum, *Blumea* 22: 232 (1975)
Plesioneuron attenuatum (Brack.) Holttum, *Blumea* 22: 245 (1975). T, I
Lastrea attenuata Brack., *U.S. Expl. Exped., Filic.* 16: 193, t. 26, f. 2 (1854); *Aspidium brackenridgei* Mett., *Ann. Sci. Nat., Bot.*, sér. 4, 15: 75 (1861); *Lastrea brackenridgei* (Mett.) Carruth., *Fl. Vit.* 359 (1873); *Nephrodium brackenridgei* (Mett.) Baker, *Syn. Fil.*, ed. 2, 494 (1874); *Dryopteris brackenridgei* (Mett.) Kuntze, *Revis. Gen. Pl.* 2: 812

(1891); *Mesoneuron brackenridgei* (Mett.) Holttum, *Dansk Bot. Ark.* 25: 44 (1967); *Thelypteris brackenridgei* (Mett.) C.F.Reed, *Phytologia* 17: 265 (1968)
Type: FRENCH POLYNESIA (Tahiti), *Wilkes Explor. Exped.* 5, holotype: US [00134978*].
Voucher: Guadalcanal, 50–300 m, 13 Jul 2016, *Chen et al. SITW11124*, BSIP!, TNM!
Note: Mettenius (1861) provided a new name for *Lastrea attenuata* Brack. because he thought Brackenridge's name was a later homonym of *Lastrea attenuata* J.Sm. However, Smith's name was not accompanied by a description or diagnosis and thus was not validly published.

Plesioneuron imbricatum (Holttum) S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 67 (2021). T, E
Pneumatopteris imbricata Holttum, *Blumea* 21: 322 (1973)
Type: INDONESIA (Maluku, Ambon), *Brooks 17775*, holotype: BM [001045052*] [001045053*]; isotypes: BO, L [0052328*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11602*, BSIP!, TNM!
Note: This species was treated in *Pneumatopteris* (Holttum, 1973; 1977; 1982; Chen et al., 2017a), but it has the deeply incised pinnae characteristic of *Plesioneuron*. The molecular phylogeny of Fawcett et al. (2021a) (based on *Chen et al. SITW4068* = *Chen Wade 3623*) found it to be nested within *Plesioneuron*, so we adopted the taxonomy proposed by Fawcett & Smith (2021).

Plesioneuron phanerophlebium (Baker) Holttum, *Blumea* 22: 243 (1975). T, A
Nephrodium phanerophlebium Baker, *Syn. Fil.*, ed. 2, 494 (1874); *Dryopteris phanerophlebia* (Baker) Kuntze, *Revis. Gen. Pl.* 2: 813 (1891); *Thelypteris phanerophlebia* (Baker) Christenh., *Global Fl.* 4: 36 (2018)
Type: SOLOMON ISLANDS, *Richards s.n.*, holotype: K [000951454*].
Note: Endemic and known only from the type collection.

Plesioneuron prenticei (Carruth.) Holttum, *Blumea* 22: 244 (1975). T, D
Lastrea prenticei Carruth., *Fl. Vit.* 359 (1873); *Nephrodium prenticei* (Carruth.) Baker, *Syn. Fil.,* ed. 2, 494 (1874); *Dryopteris prenticei* (Carruth.) Kuntze, *Revis. Gen. Pl.* 2: 813 (1891); *Thelypteris prenticei* (Carruth.) Alston, *Amer. Fern J.* 45 120 (1955)
Type: FIJI, *Milne 247*, holotype: K [000951453*].
Note: This species has been reported from the Solomon Islands (New Georgia) by Holttum (1975b), but no specimen was cited. We include the taxon in our treatment, but further study is needed to confirm its occurrence in this area.

Plesioneuron savaiense (Baker) Holttum, *Blumea* 22: 240 (1975). T, I
Nephrodium savaiense Baker, *Ann. Bot. (Oxford)* 5: 318 (1891); *Dryopteris savaiensis* (Baker) C.Chr., *Index Filic.* 291 (1905 as "*savaiiensis*") ; *Thelypteris savaiensis* (Baker) C.F.Reed, *Phytologia* 17: 312 (1968)
Type: SAMOA, *Powell 183*, lectotype: K [000951459*], designated here by Fawcett & Smith; isolectotype: K [000951458*].
Voucher: Kolombangara, 1100 m, 16 Sep 1991, *Glenny 3325*, BSIP!, WELT [P017216!].
Note: *Powell 183* in K includes two sheets with complete fronds that are likely from the same plant. We choose the complete specimen with rhizome as the lectotype.

Plesioneuron subglabrum Holttum, *Blumea* 22: 243 (1975). T, A
Thelypteris subglabra (Holttum) Christenh., *Global Fl.* 4: 38 (2018)
Type: SOLOMON ISLANDS (Santa Isabel), *Braithwaite RSS 4512*, holotype: K [K000951456*] [000951457*].
Voucher: San Jorge, 200–450 m, 6 Jun 2016, *Chen et al. SITW10504*, BSIP!, TAIF [498611!] [498612!] [498613!] [498614!] [519886!] [519887!], TNM!, UC [2048662!].
Note: Endemic. *Braithwaite RSS 4512* in K comprises two sheets and they are clearly labelled as being part of a single specimen; in accordance with ICN Art. 8.3 (Turland et al., 2018), we consider them as parts of the holotype. In the phylogenetic analysis of Fawcett et al. (2021a), this taxon (based on *Chen et al. SITW10504*) was sister to the Fijian endemic, *P. archboldiae* (Copel.) Holttum, and this clade was in turn sister to the rest of *Plesioneuron*.

PNEUMATOPTERIS Nakai, *Bot. Mag.* 47: 179 (1933)
Pneumatopteris glandulifera (Brack.) Holttum, *Blumea* 21: 302 (1973). T, D
Goniopteris glandulifera Brack., *U.S. Expl. Exped., Filic.* 16: 29 (1854); *Aspidium glanduliferum* (Brack.) Mett., *Ann. Mus. Bot. Lugduno-Batavi* 1: 232 (1864); *Cyclosorus glanduliferus* (Brack.) Copel., *Ann. Cryptog. Phytopathol.* 5: 142 [*Gen. Fil.*] (1947); *Thelypteris glandulifera* (Brack.) C.F.Reed, *Phytologia* 17: 278 (1968)
Type: SAMOA, *Wilkes Explor. Exped. s.n.*, holotype: US [00810746*].
Voucher: Kolombangara, 600–700 m, 5 Nov 2013, *Chen et al. SITW04057*, BSIP!, TAIF [460011!] [460012!] [460013!] [460014!] [460015!], TNM!
Note: This is the only species of *Pneumatopteris s.s.* known from the Solomon Islands. The genus was redefined with a narrow circumscription by Fawcett & Smith (2021), in the light of its sister relationship to members of *Sphaerostephanos*. Many species of *Pneumatopteris* sensu Holttum (1973, 1977, 1982) are recognised in the segregate genus *Reholttumia*. A collection of *P. glandulifera* from Santa Cruz, *Chen et al. SITW11069*, was included in the phylogeny of Fawcett et al. (2021a).

REHOLTTUMIA S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 76 (2021)
Reholttumia costata (Brack.) S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 77 (2021). T, K
Goniopteris costata Brack., *U.S. Expl. Exped., Filic.* 16: 28 (1854); *Nephrodium costatum* Diels, *Nat. Pflanzenfam.* 1(4): 179 (1899), *non* Bedd., *Ferns Brit. Ind.* 1: t.220 (1867); *Dryopteris costata* (Brack.) Maxon, *Univ. Calif. Publ. Bot.* 12: 26 (1924); *Cyclosorus costatus* (Brack.) Ching, *Bull. Fan Mem. Inst. Biol.* 10: 243 (1941); *Thelypteris costata* (Brack.) C.F.Reed, *Phytologia* 17: 269 (1968); *Pneumatopteris costata* (Brack.) Holttum, *Blumea* 21: 305 (1973)
Type: FIJI, *Wilkes Explor. Exped. 3*, holotype: US [00135029*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11188*, BSIP!, TNM!
Note: *Reholttumia costata* resolved in a clade with *R. macroptera* (Copel.) S.E.Fawc. & A.R.Sm. and *R. magnifica* (Copel.) S.E.Fawc. & A.R.Sm. in the phylogenetic analysis of Fawcett et al. (2021a).

Reholttumia magnifica (Copel.) S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 78 (2021). T, C
Dryopteris magnifica Copel., *Bull. Bernice P. Bishop Mus.* 69: 11 (1929); *Cyclosorus magnificus* (Copel.) Ching, *Bull. Fan Mem. Inst. Biol.* 10: 246 (1941); *Pneumatopteris*

magnifica (Copel.) Holttum, *Blumea* 21: 319 (1973); *Thelypteris magnifica* (Copel.) C.F.Reed, *Phytologia* 17: 291 (1968)
Type: FIJI (Viti Levu), *Parks 20187A*, lectotype: UC [361103*], designated by Holttum (1973); isolectotypes: BISH, P [02141989*].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10556*, BSIP!, TAIF [498576!] [498577!] [498578!] [498579!] [520590!] [520591!], TNM!, UC [2048650!] [2048651!].
Note: Two specimens from Santa Cruz, *Chen et al. SITW11089* and *Chen et al. SITW10556* were included in the phylogenetic analysis of Fawcett et al. (2021a), and together these resolved as sister to *R. costata* plus *R. macroptera*.

Reholttumia oxyoura (Copel.) S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 78 (2021). T, A
Dryopteris oxyoura Copel., *Philipp. J. Sci*. 60: 107, t. 12 (1936); *Cyclosorus oxyourus* (Copel.) Copel., *Ann. Cryptog. Phytopathol*. 5: 143 [*Gen. Fil*.] (1947); *Thelypteris oxyoura* (Copel.) C.F.Reed, *Phytologia* 17: 299 (1968); *Pneumatopteris oxyoura* (Copel.) Holttum, *Blumea* 21: 315 (1973)
Type: SOLOMON ISLANDS (Makira), *Brass 2696*, holotype: PNH, destroyed; lectotype: MICH [1003437A!] [1003437B!], designated here by Fawcett & Smith; isolectotypes: BRI-AQ [0024514*], K [000951551*], P [00636816*], UC [574163!].
Voucher: Makira, 910 m, 1 Jul 2015, *Chen et al. SITW06908*, BSIP!, TAIF [482834!], TNM!
Note: Endemic. The holotype at PNH (Copeland 1936) was destroyed, but Holttum (1977) erroneously cited the MICH isotype as the "holotype". Because Copeland previously designated a different specimen as the holotype, we designated the MICH isotype as a lectotype.

Reholttumia rodigasiana (T.Moore) S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 78 (2021). T, D
Nephrodium rodigasianum T.Moore, *Ill. Hort*. 29: 27, t.442 (1882); *Dryopteris rodigasiana* (T.Moore) C.Chr., *Index Filic*. 289 (1905); *Cyclosorus rodigasianus* (T.Moore) Ching, *Bull. Fan Mem. Inst. Biol.* 10: 248 (1941); *Thelypteris rodigasiana* (T.Moore) C.F.Reed, *Phytologia* 17: 310 (1968); *Pneumatopteris rodigasiana* (T.Moore) Holttum, *Blumea* 21: 319 (1973)
Type: SAMOA, *s.c., s.n.*, holotype: K [000951570*] [000951571*].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10513*, BSIP!, TAIF [519874!] [519877!], TNM!
Note: The two sheets at K referenced above appear to represent two halves of a single frond, and we consider them parts of a single specimen. The molecular phylogeny of Fawcett et al. (2021a) inferred *R. rodigasiana* (*Chen et al. SITW11114*) to be sister to the Hawaiian endemic *R. hudsoniana* (Brack.) S.E.Fawc. & A.R.Sm.

Reholttumia sogerensis (A.Gepp) S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 78 (2021). T, H
Dryopteris sogerensis A.Gepp, *J. Bot*. 61 (Suppl.): 61 (1923); *Cyclosorus sogerensis* (A.Gepp) Ching, *Bull. Fan Mem. Inst. Biol.* 10: 249 (1941); *Thelypteris sogerensis* (A.Gepp) C.F.Reed, *Phytologia* 17: 314 (1968); *Pneumatopteris sogerensis* (A.Gepp) Holttum, *Blumea* 21: 315 (1973)

Type: PAPUA NEW GUINEA (Central Province, Sogeri), *Forbes 446*, lectotype: BM [001045044*], designated by Holttum (1973); isolectotypes: MEL [2424219*] [2424220*] [2424221*].
Note: This species has been reported from the Solomon Islands by Holttum (1982), but no specimen was cited. We included the taxon in our treatment, but further study is needed to confirm its occurrence in this area.

***Reholttumia* sp. 1.** T
Voucher: Guadalcanal, 400–800, 17 Jul 2016, *Chen et al. SITW11589,* BSIP!, TNM!, UC [2048649!].
Note: This collection was treated as *Pneumatopteris* sp. 2 in Chen et al. (2017a: 358). In the phylogenetic analysis of Fawcett et al. (2021a) this collection, along with two other collections of *Reholttumia* from the Solomon Islands (a second collection from Guadalcanal, *Chen et al. SITW11115*, TAIF, and one from Kolombangara, *Chen et al. SITW04075 = Chen Wade3630,* TAIF) formed a monophyletic clade. These may be conspecific, or closely related species, and are the subject of ongoing study.

***Reholttumia* sp. 2.** T
Voucher: Guadalcanal, 400–800, 17 Jul 2016, *Chen et al. SITW11157*, BSIP!, TNM!
Note: This collection was treated as *Sphaerostephanos* sp. 3 in Chen et al. (2017a: 376) and was included in the phylogenetic study of Fawcett et al. (2021a). It unexpectedly resolved as sister to a large clade that included all members of *Pneumatopteris s.s.*, *Pronephrium s.s.*, *Sphaerostephanos*, and *Reholttumia*. Morphologically it is similar to members of *Reholttumia* and resolves among them in many individual gene trees. Its phylogenetic position may possibly be the result of contamination or sequencing error and needs additional study.

***Reholttumia* sp. 3.** T
Voucher: Kolombangara, 100–350 m, 22 Jul 2015, *Chen et al. SITW07640*, BSIP!, TAIF [486571!] [486572!] [486573!], TNM!
Note: This collection was treated as *Pneumatopteris* sp. 3 in Chen et al. (2017a: 359). It is distinctive in having large indusia and sori restricted to the proximal portion of the segments. It needs further study.

***Reholttumia* sp. 4.** T
Voucher: Rennell, 20–50 m, 3 Jul 2014, *Chen et al. SITW05337*, BSIP!, TAIF [471915!] [471916!] [471917!] [471918!], TNM!
Note: This entity is known only from a few collections from Rennell island and was described by Glenny in his unpublished manuscript as "*Pneumatopteris rennellii*". It has tiny, shriveled indusia, glandular sporangia, and very distinctive venation: the secondary veins irregularly unite to form a sub-marginal connecting vein that runs parallel to the segment margin towards the segment apex, in contrast to the typical pattern of secondary veins terminating at or near the margin. Some specimens from Rennell have abortive sporangia and irregular margins and venation, which may suggest hybridization. Additional study is needed.

SPHAEROSTEPHANOS J.Sm., *Gen. pl.* 24 (1839)

Sphaerostephanos beccarianus (Ces.) S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 81 (2021). T, I
Meniscium beccarianum Ces., *Rendiconto Reale Accad. Sci. Fis.* 16: 27, 30 (1877); *Dryopteris cesatiana* C.Chr., *Index Filic.* 257 (1905), *nom. superfl.*; *Phegopteris beccariana* (Ces.) Alderw., *Malayan Ferns* 509 (1909); *Cyclosorus beccarianus* (Ces.) Copel., *Ann. Cryptog. Phytopathol.* 5: 142 [*Gen. Fil.*] (1947); *Pronephrium beccarianum* (Ces.) Holttum, *Blumea* 20: 107 (1972)
Type: INDONESIA (Indonesian New Guinea), *Beccari 17727*, holotype: FI [013617*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11648*, BSIP!, TNM!
Note: This species was recently transferred from *Pronephrium* to *Sphaerostephanos* by Fawcett & Smith (2021). A Fijian specimen resolved in a clade with other species having less-divided or entire laminae in the phylogeny of Fawcett et al. (2021a). This group of species were previously treated in *Pronephrium* and included *S. brauseanus* (Holttum) S.E.Fawc. & A.R.Sm. and *S. womersleyi* (Holttum) S.E.Fawc. & A.R.Sm. (Holttum, 1972; 1977; 1982).

Sphaerostephanos braithwaitei Holttum, *Allertonia* 1(3): 206 (1977). T, B
Thelypteris braithwaitei (Holttum) Christenh., *Global Fl.* 4: 28 (2018)
Type: SOLOMON ISLANDS (Guadalcanal), *Braithwaite RSS 4088*, holotype: K.
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05651*, BSIP!, TAIF [473086!] [473087!] [473088!] [473089!], TNM!
Note: This species (based on *Chen et al. SITW11593*) resolved with *Sphaerostephanos cataractorum* (W.H.Wagner & Grether) Holttum and *S. vestigiatus* (Copel.) Holttum in the phylogeny of Fawcett et al. (2021a).

Sphaerostephanos doodioides (Copel.) Holttum, *Allertonia* 1(3): 203 (1977). T, D
Dryopteris doodioides Copel., *Philipp. J. Sci.* 60: 107, t. 11 (1936); *Cyclosorus doodioides* (Copel.) Copel., *Ann. Cryptog. Phytopathol.* 5: 142 [*Gen. Fil.*] (1947); *Thelypteris doodioides* (Copel.) C.F.Reed, *Phytologia* 17: 273 (1968)
Type: SOLOMON ISLANDS (Makira), *Brass 3004*, holotype: PNH, destroyed; lectotype: GH [00021041*], designated here by Fawcett & Smith; isolectotypes: BRI-AQ [0024518*], MICH [1190422*].
Voucher: Guadalcanal, 50–200 m, 23 Jul 2014, *Chen et al. SITW05702*, BSIP!, TAIF [471952!], TNM!
Note: The holotype at PNH (Copeland,1936) was destroyed, but Holttum (1977) erroneously cited the GH isotype as the "holotype". Because Copeland previously designated a different specimen as the holotype, we designate the GH isotype as a lectotype. The phylogenetic study of Fawcett et al. (2021a) included a specimen from Guadalcanal, *Chen Wade 3113*, which resolved as sister to *Sphaerostephanos warburgii* (Kuhn & C.Chr.) Holttum.

Sphaerostephanos gregarius (Copel.) Holttum, *Fl. Males., ser. 2, Pterid.* 1(5): 480 (1982). T, E
Cyclosorus gregarius Copel., *J. Arnold Arbor.* 24: 440 (1943); *Thelypteris gregaria* (Copel.) C.F.Reed, *Phytologia* 17: 280 (1968)
Type: PAPUA NEW GUINEA (Western or Gulf Provinces, Fly River), *Brass 6759*, holotype: MICH [1190297*]; isotypes: BM [001044874*], BO, L [00523120*], BRI-AQ [0024882*], GH [00020931*].

Voucher: Shortland, 260 m, 17 Nov 1990, *Glenny 2707*, WELT [P016772!, four sheets].
Note: Dubiously distinct from *S. veitchii* Holttum., but we retained it here pending further research.

Sphaerostephanos heterocarpos (Blume) Holttum, *Companion Handb. Ferns Brit. Ind.* 209 (1974). T, S
Aspidium heterocarpon Blume, *Enum. Pl. Javae* 2: 155 (1828); *Nephrodium heterocarpon* (Blume) T.Moore, *Index Fil.* 5: 93 (1858); *Dryopteris heterocarpa* (Blume) Kuntze, *Revis. Gen. Pl.* 2: 813 (1891); *Cyclosorus heterocarpos* (Blume) Ching, *Bull. Fan Mem. Inst. Biol.* 8: 180 (1938); *Thelypteris heterocarpa* (Blume) C.V.Morton, *Amer. Fern J.* 49(3): 113 (1959)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L [0052322*], designated by Holttum (1982); isolectotypes: L [0063153*] [0931048*], BM [1044994*].
Voucher: Vanikoro, 70 m, 26 Jun 2016, *Chen et al. SITW11079*, BSIP!, TNM!, VT [290578!].
Note: Holttum (1982) cited the old barcode 908,332-1158 when selecting a lectotype, and this is considered as a mistake for 908,332-1156 (= 0052322); it is the only one of four digitised *S. heterocarpos* specimens clearly collected by Blume with a similar barcode. Stearn (1973) has shown the correct feminine termination of the epithet in Greek is "heterocarpos", rather than "heterocarpus" as adopted by Chen et al. (2017a). This widespread and variable taxon may represent a species complex and is in need of further study.

Sphaerostephanos metcalfei (Baker) Holttum, *Allertonia* 1(3): 207 (1977). T, C
Polypodium metcalfei Baker, *Ann. Bot. (Oxford)* 5: 461 (1891); *Dryopteris metcalfei* (Baker) C.Chr., *Index Filic.* 277 (1905); *Thelypteris metcalfei* (Baker) C.F.Reed, *Phytologia* 17: 293 (1968)
Type: SOLOMON ISLANDS (Santa Cruz Islands), *Metcalfe s.n.*, holotype: K [000932925*].
Note: Known only from the type collection.

Sphaerostephanos polycarpos (Blume) Copel., *Univ. Calif. Publ. Bot.* 16: 60 (1929). T, N
Aspidium polycarpon Blume, *Enum. Pl. Javae* 2: 156 (1828); *Didymochlaena polycarpa* (Blume) Baker; *Syn. Fil.* 248 (1867); *Nephrodium polycarpon* (Blume) Keyserl., *Pol. Cyath. Hb. Bung.* 7 (1873); *Mesochlaena polycarpa* (Blume) Bedd., *Suppl. Ferns S. Ind.* 13 (1876); *Dryopteris polycarpa* (Blume) Christ, *Philipp. J. Sci., C.* 2: 202 (1907); *Cyclosorus polycarpos* (Blume) Holttum, *Rev. Fl. Mal.* 2: 283, f. 164 (1955); *Thelypteris polycarpa* (Blume) K.Iwats., *Mem. Coll. Sci. Univ. Kyoto, B, Biol.* 31: 32 (1964)
Type: INDONESIA (Java), *Blume s.n.*, holotype: L: [0063130*], isotypes: BM [001044994*], K [000397776*].
Voucher: Santa Cruz, 100–370 m, 24 Jun 2016, *Chen et al. SITW11070*, BSIP!, TNM!
Note: Stearn (1973) has shown the correct feminine termination of the epithet in Greek is "polycarpos", rather than "polycarpus" as adopted by Chen et al. (2017a). *Sphaerostephanos unijuga* Copel., described from Makira, is a synonym of this species. *Sphaerostephanos polycarpos* is the type species of the genus, and together with *S. hochreutineri* (C.Chr.) Holttum, it is sister to all other members of *Sphaerostephanos s.s.* (Fawcett et al., 2021a).

Sphaerostephanos richardsii (Baker) Holttum, *Allertonia* 1(3): 205 (1977). T, D
Nephrodium richardsii Baker, *Syn. Fil.,* ed. 2, 494 (1874); *Cyclosorus richardsii* (Baker) Brownlie, *Fl. Nouv.-Caléd.* 3: 218 (1969); *Thelypteris richardsii* (Baker) Christenh., *Global Fl.* 4: 36 (2018)
Type: NEW CALEDONIA, *Richards s.n.*, holotype: K [000932956*]; isotype: L [0063406].
Voucher: Kolombangara, 360 m, 18 Jul 1990, *Glenny 2234*, WELT [P016596!, three sheets].

Sphaerostephanos scandens Holttum, *Allertonia* 1(3): 211 (1977). E, A
Thelypteris scandens (Holttum) Christenh., *Global Fl.* 4: 37 (2018)
Type: SOLOMON ISLANDS (Guadalcanal), *Braithwaite RSS 4784*, holotype: K [000932958*]; isotypes: BSIP!, L [0629800*] [0629801*], CANB [310603*].
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05652*, BSIP!, TAIF [473046!] [473047!], TNM!
Note: This species is endemic and highly distinctive with its long-creeping, climbing rhizomes. Based on the phylogenetic analysis of Fawcett et al. (2021a), *S. scandens* (based on *Chen et al. SITW3403 = Chen Wade 2965*) was nested within *Sphaerostephanos s.s.* and not closely related to *S. invisus* (transferred to *Strophocaulon* by Fawcett & Smith 2021), with which Holttum (1977) compared it.

Sphaerostephanos veitchii Holttum, *Allertonia* 1: 204 (1977). T, B
Thelypteris veitchii (Holttum) Christenh., *Global Fl.* 4: 39 (2018)
Type: SOLOMON ISLANDS (Makira), *Veitch s.n.*, holotype: K [000934718*].
Voucher: Malaita, 150–350 m, 22 Jul 2015, *Chen et al. SITW07690*, BSIP!, TAIF [486693!], TNM!, VT [286620!].
Note: *Nephrodium amboinense* var. *subglandulosum* Baker, described from Makira, is a synonym of this species. Based on phylogenetic analysis of Fawcett et al. (2021a), this species (based on *Chen et al. SITW3062 = Chen Wade 2816*) was sister to *S. hastatopinnatus* (Brause) Holttum.

Sphaerostephanos womersleyi (Holttum) S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 82 (2021). T, E
Pronephrium womersleyi Holttum, *Blumea* 20: 108 (1972); *Thelypteris womersleyi* (Holttum) Christenh., *Global Fl.* 4: 40 (2018)
Type: PAPUA NEW GUINEA (Eastern Highlands), *Floyd & Womersley NGF 6308*, holotype: LAE; isotypes: BM [001044859*], BRI-AQ [0024896*].
Voucher: Guadalcanal, 1767 m [5800 ft], 30 Oct 1965, *Braithwaite RSS 4714*, L [3605702*].
Note: This species was treated as *Pronephrium* by Holttum (1977, 1982), but was transferred to *Sphaerostephanos* by Fawcett and Smith (2021), based on morphological and molecular data.

***Sphaerostephanos* sp. 1.** T
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11650,* BSIP! TNM!, UC [2048648!].
Note: This species is the same *Sphaerostephanos* sp. 1 of Chen et al. (2017a: 372–373).

It has distinctive long hairs on the adaxial axes and laminae. It was included in the phylogeny of Fawcett et al. (2021a) and resolved as sister to *S. hirsutus* plus *S. latebrosus*, both from Sulawesi.

***Sphaerostephanos* sp. 2.** T
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11579*, BSIP! TNM!
Note: This species is the same as *Sphaerostephanos* sp. 2 of Chen et al. (2017a: 374–375). It is the largest species of the genus in the Solomon Islands, with fronds often over 2 m long.

STROPHOCAULON S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 87 (2021)
Strophocaulon invisus (G.Forst.) S.E.Fawc. & A.R.Sm., *Gen. Classific. Thelypterid.* 88 (2021). T, I
Polypodium invisum G.Forst., *Fl. Ins. Austr.* 81 (1786); *Nephrodium invisum* (G.Forst.) Carruth., *Fl. Vit.* 362 (1873); *Dryopteris invisa* (G.Forst.) Kuntze, *Revis. Gen. Pl.* 2: 813 (1891); *Aspidium invisum* (G.Forst.) Christ, *Bot. Jahrb. Syst.* 23(3): 350 (1896), *non* Sw., *J. Bot. (Schrader)* 1800(2): 34 (1801); *Cyclosorus invisus* (G.Forst.) Copel., *Ann. Cryptog. Phytopathol.* 5: 142 [*Gen. Fil.*] (1947); *Sphaerostephanos invisus* (G.Forst.) Holttum, *Webbia* 30: 195 (1976); *Christella invisa* (G.Forst.) Pic.Serm., *Webbia* 31(1): 252 (1977)
Type: FRENCH POLYNESIA (Tahiti), *Forster s.n.*, lectotype: BM [001048418*], designated by Bobrov (1980); isolectotypes: K, LE [00008736*].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10524*, BSIP!, TAIF [519910!] [519911!], TNM!
Note: This taxon and *S. unitum* were treated in *Sphaerostephanos* by Chen et al. (2017a) but transferred to *Strophocaulon* by Fawcett & Smith (2021). *Strophocaulon* is an evolutionarily isolated lineage sister to a clade that includes all members of the genera *Pneumatopteris s.s.*, *Pronephrium s.s.*, *Reholttumia*, and *Sphaerostephanos* (Fawcett et al., 2021a). It is distinctive in having very long-creeping subterranean rhizomes.

Strophocaulon unitum (L.) S.E.Fawc. & A.R.Sm. *Gen. Classific. Thelypterid.* 88 (2021). T, I
Polypodium unitum L., *Syst. Nat.*, ed. 10, 2: 1326 (1759); *Cyclosorus unitus* (L.) Ching, *Bull. Fan Mem. Inst. Biol.* 8: 192 (1938); *Sphaerostephanos unitus* (L.) Holttum, *J. S. African Bot.* 40: 165 (1974); *Thelypteris unita* (L.) C.V.Morton, *Amer. Fern J.* 49(3): 113 (1959)
Type: UNKNOWN, *s.c., s.n.*, lectotype: LINN-HL [1251-21*], designated by Holttum (1974b).
Voucher: Malaita, 150–350 m, 22 Jul 2015, *Chen et al. SITW07609*, BSIP!, TAIF [486626!], TNM!
Note: The lectotype, presumably studied by Linnaeus, best matches specimens from South India (Holttum, 1974b). Also in the Linnaean herbarium is LINN-HL [1251-22], which appears to represent *Cyclosorus s.s.* Specimens from the Solomon Islands are most similar to *Sphaerostephanos unitus* (L.) Holttum var. *mucronatus* Christ, based on *Cuming 182* from the Philippines (Holttum, 1982); we refrained from making an infraspecific combination in *Strophocaulon*, pending further study.

DIDYMOCHLAENACEAE Ching ex Li Bing Zhang & Liang Zhang, *Taxon* 64(1): 34

(2015)
DIDYMOCHLAENA Desv., *Ges. Naturf. Freunde Berlin Mag. Neuesten Entdeck. Gesammten Naturk.* 5: 303 (1811)
Didymochlaena truncatula (Sw.) J.Sm., *J. Bot.* 4: 196 (1841). T, T
Adiantum lunulatum Houtt., *Nat. Hist.* 14: 209 (1783), *non* Burm.f., *Fl. Indica* 235 (1768); *Aspidium truncatulum* Sw., *J. Bot. (Schrader)* 1800 (2): 36 (1801)
Type: INDONESIA (Java), *Popta 425*, lectotype: L [3532310*], designated by Shang et al. 2021; isolectotype: L [3532311*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11621*, BSIP!, TNM!
Note: Shang et al. (2021) proposed a much narrower circumscription of *D. truncatula* and described four new species, including *D. solomonensis* Li Bing Zhang & H.Shang from the Solomon Islands. While there is some genetic and morphological variation within *D. truncatula s.l.*, the support for their classification seems weak; therefore, we chose to recognise a broadly defined *D. truncatula*.

HYPODEMATIACEAE Ching, *Acta Phytotax. Sin.* 13(1): 96 (1975)
LEUCOSTEGIA C.Presl, *Tent. Pterid.* 94 (1836)
Leucostegia pallida (Mett. ex Kuhn) Copel., *Philipp. J. Sci.* 34: 252 (1927). E, N
Davallia pallida Mett. ex Kuhn, *Linnaea* 36: 142 (1869)
Type: VANUATU, *MacGillivray 93*, lectotype: B [20 0044559*], designated here by Chen; isolectotypes: B [20 0044562*], BM [001045918*], K [000061891*], P [00630955*] [00630956*] [00630957*].
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05413*, BSIP!, TAIF [471814!], TNM!
Note: We selected the only specimen with Mettenius' annotation as lectotype among the known original materials, although it is only fragments and likely not the one measured by Mettenius when preparing the protologue. There is an inconsistency in the collector's name on the original materials: Cuming was cited in the protologue and the lectotype, but MacGillivray was cited on other specimens. According to Dance (1980), Cuming was very sick from 1846, and it seems unlikely that he is the collector of the types that were made in 1859 (Cuming was 69 years old at that time).

DRYOPTERIDACEAE Herter, *Revista Sudamer. Bot.* 9(1): 15 (1949)
ARACHNIODES Blume, *Enum. Pl. Javae* 2: 241 (1828)
Arachniodes aristata (G.Forst.) Tindale, *Contr. New South Wales Natl. Herb.* 3: 89 (1961). T, J
Polypodium aristatum G.Forst., *Fl. Ins. Austr.* 82 (1786); *Aspidium aristatum* (G.Forst.) Sw., *J. Bot. (Schrader)* 1800(2): 37 (1801); *Nephrodium aristatum* (G.Forst.) C.Presl, *Reliq. Haenk.* 1: 37 (1825); *Polystichum aristatum* (G.Forst.) C.Presl, *Tent. Pterid.* 83 (1836); *Lastrea aristata* (G.Forst.) T.Moore, *Index Fil.* 5: 85 (1858); *Dryopteris aristata* (G.Forst.) Kuntze, *Revis. Gen. Pl.* 2: 812 (1891); *Rumohra aristata* (G.Forst.) Ching, *Sinensia* 5: 50 (1934); *Polystichopsis aristata* (G.Forst.) Holttum, *Rev. Fl. Malaya* 2: 486, f.287 (1955); *Byrsopteris aristata* (G.Forst.) Morton, *Amer. Fern J.* 50(1): 152 (1960)
Type: FRENCH POLYNESIA (Tahiti), *Forster 294*, lectotype: BM [001048414*], designated by Morton (1960).
Voucher: Guadalcanal, 1250 m, 16 Sep 2015, *Perrie 7328 & Pene*, BSIP!, SUVA!, WELT [P028419!].

Note: Newly recorded from the Solomon Islands.
ARTHROBOTRYA J.Sm., *Hist. Fil.* 141 (1875)
Arthrobotrya articulata (J.Sm. ex Fée) J.Sm., *Hist. Fil.* 141 (1875). E, E
Polybotrya articulata J.Sm. ex Fée, *Mém. Foug.* 2: 74, t. 37 [*Hist. Acrostich.*] (1845); *Acrostichum articulatum* (J.Sm. ex Fée) Hook., *Sp. Fil.* 5: 247 (1864); *Teratophyllum articulatum* (J.Sm. ex Fée) Mett. ex Kuhn, *Ann. Mus. Bot. Lugd.-Bat.* 4: 297 (1869); *Lomagramma articulata* (J.Sm. ex Fée) Copel., *Philipp. J. Sci., C.* 3: 32 (1908)
Type: PHILIPPINES (Luzon), *Cuming 296*, lectotype: BM [001066148*], designated here by Chen; isolectotypes: B [20 0146894*] [20 0146895*], BM [001066146*] [001066147*], FI [004212*], K [000604186*] [000604187*] [000604188*] [000604189*] [000604190*], LE [00008176*], MICH [1191386*], P [00603609*] [00603610*], US [00135380*].
Voucher: Guadalcanal, 400–1000 m, 30 Jun 2014, *Chen et al. SITW05289*, BSIP!, TAIF [464780!], TNM!
Note: There are two sheets of *Cuming 296* in John Smith's herbarium in BM; we selected the one with both sterile and fertile fronds as lectotype.

BOLBITIS Schott, *Gen. Fil.* 1, pl. 14 (1834)
Bolbitis heteroclita (C.Presl) Ching, *Index Filic. Suppl. Tert.* 48 (1934). T, S
Acrostichum heteroclitum C.Presl, *Reliq. Haenk.* 1: 15, t. 2, f. 2 (1825)
Type: PHILIPPINES (Luzon), *Haenke s.n.*, lectotype: PRC, designated by Field (2020); isolectotypes: B [20 0144932*] [20 0144933*], BR [006981976*], K [000670341*].
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05378*, BSIP!, TNM!

Bolbitis quoyana (Gaudich.) Ching, *Index Filic. Suppl. Tert.* 49 (1934). T, S
Acrostichum quoyanum Gaudich., *Voy. Uranie* 306, t. 3 (1828)
Type: INDONESIA (Maluku, Pulau Pisang), *Gaudichaud s.n.*, lectotype: P [00630864*], designated by Field (2020); isolectotype: FI [004201*].
Voucher: Ranongga, 400–700 m, 16 Aug 2013, *Chen et al. SITW03065*, BSIP!, TAIF [445058*] [445059*], TNM!

Bolbitis rivularis (Brack.) Ching, *Index Filic. Suppl. Tert.* 50 (1934). T, D
Cyrtogonium rivulare Brack., *U.S. Expl. Exped., Filic.* 16: 85, t. 11, f. 3 (1854); *Neurocallis rivularis* (Brack.) T.Moore, *Index Fil.* 276 (1861); *Acrostichum rivulare* (Brack.) Hook., *Sp. Fil.* 5: 263 (1864); *Poecilopteris rivularis* (Brack.) Carruth., *Fl. Vit.* 374 (1873); *Leptochilus rivularis* (Brack.) C.Chr., *Index Filic.* 387 (1906); *Campium rivulare* (Brack.) Copel., *Philipp. J. Sci., C.* 37: 373, f. 27, pl. 20 (1928)
Type: FIJI, *Wilkes Explor. Exped. 1*, holotype: US [00135373*].
Voucher: Vanikoro, 20–150 m, 21 Jun 2016, *Chen et al. SITW11051*, BSIP!, TNM!

CTENITIS (C.Chr.) C.Chr., *Man. pterid.* 554 (1938)
Ctenitis aciculata (Baker) Ching, *Bull. Fan Mem. Inst. Biol.* 8: 292 (1938). T, E
Nephrodium aciculatum Baker, *J. Linn. Soc., Bot.* 22: 226 (1886); *Dryopteris aciculata* (Baker) C.Chr., *Index Filic.* 250 (1905)
Type: MALAYSIA (Sarawak), *Hose 86*, lectotype: K [000235575*], designated here by Chen; isolectotypes: BM [001048496*], K [000235576*] [000235577*], P [00642672*].
Voucher: Kolombangara, 600–700 m, 5 Aug 2013, *Chen et al. SITW02972*, BSIP!, TAIF [445138!], TNM!

Note: There are three syntypes in K; we selected the one with a complete frond as lectotype.

DRYOPTERIS Adans., *Fam. pl.* 2: 20, 551 (1763), *nom. cons.*
Dryopteris arborescens (Baker) Kuntze, *Revis. Gen. Pl.* 2: 812 (1891). T, D
Nephrodium arborescens Baker, *Syn. Fil.* 286 (1868); *Aspidium arborescens* (Baker) Luerss., *Fil. Graeff.* 176 (1871)
Type: SAMOA, *Powell s.n.*, lectotype: K [001080955*], designated here by Chen; isolectotype: K [001080956*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11140*, BSIP!, TNM!
Note: Baker (1891) proposed to drop his own name *Nephrodium arborescens* because he realised this species was not arborescent. He published two new names, *N. ludens* Baker (based on *Powell 87 & 167*) and *N. powellii* Baker (based on *Powell 245*), to replace *N. arborescens*. But this has no effect on the validity of *N. arborescens*. We agree with Christensen (1943) who treated both *N. ludens* and *N. powellii* as synonyms of *N. arborescens*. *Powell s.n.* in K comprises two sheets, and they are considered as duplicates because they are not clearly labelled as being part of a single specimen. We selected the one bearing Baker's annotation "the original plant" as lectotype.

Dryopteris hasseltii (Blume) C.Chr., *Index Filic.* 269 (1905). T, S
Polypodium hasseltii Blume, *Fl. Javae* 195, t. 92 (1829)
Type: INDONESIA (Java), *Zippelius s.n.*, lectotype: L [0051589*], designated by Fraser-Jenkins (1989).
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11133*, BSIP!, TNM!
Note: *Dryopteris odontophora* Copel., described from Guadalcanal, is a synonym of this species.

Dryopteris nodosa (C.Presl) Li Bing Zhang, *Taxon* 61(6): 1208 (2012). T, L
Acrophorus nodosus C.Presl, *Tent. Pterid.* 94, t. 3, f. 2. 1836; *Davallia nodosa* (C.Presl) Hook., *Sp. Fil.* 1: 157 (1846); *Cystopteris nodosa* (C.Presl) Mett., *Ann. Mus. Bot. Lugd.-Bat.* 1: 241 (1864); *Leucostegia nodosa* (C.Presl) *Bedd., Handb. Ferns Brit. Ind., Suppl.* 4 (1870); *Peranema nodosum* (C.Presl) Fraser-Jenk., *Taxon. Revis. Indian Subcontinental Pteridophytes* 317 (2008)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L [0063159*], designated by Zhang & Zhang (2012); isolectotypes: L [0063160*] [0063161*] [0063162*] [0063163*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11616*, BSIP!, TNM!

Dryopteris papuana C.Chr., *Index Filic.* 282 (1905). T, B
Nephrodium dissitifolium Baker, *Bull. Misc. Inform. Kew* 1899(151-152): 120 (1899)
Type: PAPUA NEW GUINEA, *Giulianetti 93*, holotype: K [001080960*]; isotype: K [000689547*].
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04931*, BSIP!, TAIF [463829!], TNM!
Note: Transfer of *Nephrodium dissitifolium* to *Dryopteris* was blocked by an earlier name *Dryopteris dissitifolia* (Baker) C.Chr. (=*Athyrium dissitifolium* (Baker) C.Chr.); therefore, Christensen (1905–1906) provided a new name for it.

Dryopteris sparsa (D.Don) Kuntze, *Revis. Gen. Pl.* 2: 813 (1891). T, Q

Nephrodium sparsum D.Don, *Prodr. Fl. Nepal.* 6 (1825)
Type: NEPAL (Suembu), *Buchanan s.n.*, lectotype: BM [001066027], designated by Fraser-Jenkins (1989).
Voucher: Guadalcanal, 1706 m [5600 ft], 30 Oct 1965, *Braithwaite RSS 4719*, L [3551768*].

ELAPHOGLOSSUM Schott ex J.Sm., *J. Bot.* 4: 148 (1842)
Elaphoglossum blumeanum (Fée) J.Sm., *Ferns Brit. For.* 106 (1866). E, E
Acrostichum blumeanum Fée, *Mém. Foug.* 2: 62 [*Hist. Acrostich.*] (1845)
Type: PHILIPPINES (Luzon), *Cuming 194*, holotype: P [00523032*]; isotypes: BM [000592481*], MICH [1190001*], P [00523033*] [00523034*], RB [00671643*], UC [414462*].
Voucher: Kolombangara, 1000–1200 m, 14 Oct 2012, *Chen et al. SITW00848*, BSIP!, TAIF [421195!], TNM!

Elaphoglossum novoguineense Rosenst., *Repert. Spec. Nov. Regni Veg.* 10: 341 (1912). E, B
Type: PAPUA NEW GUINEA, *Bamler 67*, lectotype: UC [391617*], designated here by Chen.
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11147*, BSIP!, TNM!
Note: The sheet in UC is the only known original material; therefore, we selected it as lectotype.

LOMAGRAMMA J.Sm., *J. Bot.* 3: 402 (1841)
Lomagramma brassii Holttum, *Blumea* 14: 224 (1966). E, B
Type: PAPUA NEW GUINEA, *Brass 24947*, holotype: A [00021546*].
Voucher: Guadalcanal, 650 m, 21 Oct 1991, *Glenny 3363*, BSIP!, WELT [P017250!].

Lomagramma cordipinna Holttum, *Gard. Bull. Straits Settlem.* 9: 202 (1937). E, D
Type: SAMOA, *Safford 7*, holotype: US [00135386] [00135387*] [00135388*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10466*, BSIP!, TAIF [498621!] [498622!] [519960!], TNM!

Lomagramma cultrata (Baker) Holttum, *Gard. Bull. Straits Settlem.* 9: 203 (1937). E, A
Acrostichum cultratum Baker, *Syn. Fil.*, ed. 2, 524 (1874)
Type: SOLOMON ISLANDS (Makira), *Richards s.n.*, holotype: K [001094229*].
Note: Endemic and known only from the type collection.

Lomagramma polyphylla Brack., *U.S. Expl. Exped., Filic.* 16: 83, t.12, f.1 (1854). E, C
Neurocallis polyphylla (Brack.) T.Moore, *Index Fil.* 19 (1857); *Acrostichum polyphyllum* (Brack.) Hook., *Sp. Fil.* 5: 243 (1864); *Lomariopsis polyphylla* (Brack.) Kuhn, *Verh. K.K. Zool.-Bot. Ges. Wien* 19: 571 (1869), *non* Kuhn, *Filic. Afr.* 54 (1868); *Chrysodium polyphyllum* (Brack.) Luerss., *Fil. Graeff.* 69 (1871); *Poecilopteris polyphylla* (Brack.) Carruth., *Fl. Vit.* 374 (1873); *Polybotrya polyphylla* (Brack.) C.Chr., *Index Filic.* 15 (1905), 505 (1906)
Type: FIJI, *Wilkes Explor. Exped. 1*, holotype: US [0013589*] [0013590*].
Voucher: Vanikoro, 20–150 m, 21 Jun 2016, *Chen et al. SITW11050*, BSIP!, TAIF

[498846!] [498847!] [498848!] [498849!], TNM!
Note: Two sheets of *Wilkes Explor. Exped. 1* in US are considered as holotype because they bear a single, original label in common, which is in accordance with ICN Art. 8.3 (Turland et al., 2018).

Lomagramma sinuata C.Chr., *Svensk Bot. Tidskr.* 16(1): 98, f.1 (1922). E, E
Type: INDONESIA (Sulawesi), *Kaudern 73*, holotype: BM [001067935*]; isotypes: BO, S-P [5603*] [09-41615*].
Voucher: Rennell, 20–50 m, 3 Jul 2014, *Chen et al. SITW05344*, BSIP!, TAIF [471761!], TNM!

PLEOCNEMIA C.Presl, *Tent. Pterid.* 183 (1836)
Pleocnemia cumingiana C.Presl, *Epimel. Bot.* 50 (1851 ['1849']). T, N
Type: PHILIPPINES (Luzon), *Cuming 107*, lectotype: PRC [450259*], designated by Holttum (1951); isolectotypes: BM [001048569*] [001048571*], K [000421197*] [000421198*] [000421199*], LE [00008293*], PRC [450258*] [450260*], RB [00543373*] [00561349*] [00561350*], SING [0190489!], US [00135251*] [01100963*] [01100965*], W [0016743*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11585*, BSIP!, TAIF [498940!], TNM!
Note: This species was misidentified as *P. leuzeana* (Gaudich.) C.Presl in Chen et al. (2017a).

Pleocnemia dahlii (Hieron.) Holttum, *Fl. Males., ser. 2, Pterid.* 2(1): 20 (1991). T, N
Phegopteris dahlii Hieron., *Notizbl. Königl. Bot. Gart. Berlin* 2: 84 (1898); *Aspidium dahlii* (Hieron.) Diels, *Fl. Schutzgeb. Südsee* 116 (1901); *Dictyopteris dahlii* (Hieron.) Alderw., *Bull. Jard. Bot. Buitenzorg*, ser. 2, 7: 11 (1912); *Tectaria dahlii* (Hieron.) C.Chr., *Index Filic. Suppl. Tert.* 178 (1934)
Type: PAPUA NEW GUINEA, *Dahl s.n.*, holotype: B [20 0079838*].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10551*, BSIP!, TAIF [520539!], TNM!

Pleocnemia irregularis (C.Presl) Holttum, *Kew Bull.* 29(2): 347 (1974). T, N
Polypodium irregulare C.Presl, *Reliq. Haenk.* 1: 25, t.4 f.3 (1825); *Dictyopteris irregularis* (C.Presl) C.Presl, *Tent. Pterid.* 194, t. 8, f. 7 (1836); *Phegopteris irregularis* (C.Presl) Mett., *Ann. Mus. Bot. Lugduno-Batavi* 1: 225 (1864); *Aspidium irregulare* (C.Presl) C.Chr., *Index Filic.* 78 (1905), *non* Brack., *U.S. Expl. Exped., Filic.* 16: 180 (1854); *Tectaria irregularis* (C.Presl) Copel., *Philipp. J. Sci., C.* 2: 416 (1907); *Arcypteris irregularis* (C.Presl) Ching, *Sunyatsenia* 5: 251 (1940)
Type: PHILIPPINES, *Haenke s.n.*, holotype: PRC?
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10428*, BSIP!, TAIF [519458!], TNM!

Pleocnemia leuzeana (Gaudich.) C.Presl, *Tent. Pterid.* 184, t. 7, f. 12 (1836). T, R
Polypodium leuzeanum Gaudich., *Voy. Uranie* 361, t.6 (1829); *Aspidium leuzeanum* (Gaudich.) Kunze, *Bot. Zeitung (Berlin)* 4: 474 (1846); *Nephrodium leuzeanum* (Gaudich.) Hook., *Sp. Fil.* 4: 61 (1862); *Dryopteris leuzeana* (Gaudich.) Kuntze, *Revis. Gen. Pl.* 2: 813 (1891); *Tectaria leuzeana* (Gaud.) Copel., *Philipp. J. Sci., C.* 2: 417

(1907)
Type: INDONESIA (Maluku), *Gaudichaud s.n.*, holotype: P [01452147*] [01452338*] [04022290*] [04022291]; isotype: K [000421122*].
Voucher: Guadalcanal, 200–250 m, 21 Aug 2012, *Chen et al. SITW00188*, BSIP!, TAIF [417104!] [417105!] [417106!], TNM!

POLYSTICHUM Roth, *Tent. Fl. Germ.* 3(1.1): 31, 69 (1799), *nom. cons.*
Polystichum moluccense (Blume) T.Moore, *Index Fil.* 5: 84 (1858). E, N
Aspidium moluccense Blume, *Enum. Pl. Javae* 2: 168 (1828)
Type: INDONESIA (Maluku), *Reinwardt s.n.*, holotype: L [0051994*].
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05372*, BSIP!, TAIF [471875!] [471876!] [471877!], TNM!

NEPHROLEPIDACEAE Pic.Serm., *Webbia* 29(1): 8–11 (1975)
NEPHROLEPIS Schott, *Gen. Fil.* 1, pl. 3 (1834)
Nephrolepis biserrata (Sw.) Schott, *Gen. Fil.* ad. pl. 3 (1834). T, T
Aspidium biserratum Sw., *J. Bot. (Schrader)* 1800(2): 32 (1801); *Nephrodium biserratum* (Sw.) C.Presl, *Reliq. Haenk.* 1: 31 (1825); *Hypopeltis biserrata* (Sw.) Bory, *Voy. Indes Or.* 2: 65 (1833); *Lepidonevron biserratum* Fée, *Mém. Foug.*, 5: 301 [*Gen. Filic.*] (1852)
Type: MAURITIUS, *Grondahl s.n.*, lectotype: S-P [7416*], designated by Nauman (1981, first-step) and Field (2020, second-step); isolectotypes: S-P [7414*] [7415*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10456*, BSIP!, TAIF [519972!] [519973!], TNM!

Nephrolepis dicksonioides Christ, *Verh. Nat. Ges. Basel* 11: 241, t.3, f.8-10 (1896). T, E
Type: INDONESIA (Sulawesi), *Sarasin 1030*, lectotype: P [01572080*], designated here by Chen; isolectotype: BAS* (three sheets).
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11637*, BSIP!, TNM!
Note: Original material is known only from BAS and P; the specimens in BAS are unmounted, and the specimen in P with Christ's annotation was selected as the lectotype.

Nephrolepis hirsutula (G.Forst.) C.Presl, *Tent. Pterid.* 79 (1836). T, N
Polypodium hirsutulum G.Forst., *Fl. Ins. Austr.* 81 (1786); *Aspidium hirsutulum* (G.Forst.) Sw., *J. Bot. (Schrader)* 1800(2): 32 (1801); *Polystichum hirsutulum* (G.Forst.) Bernh., *J. Bot.* 1801(1): 16 (1802); *Nephrodium hirsutulum* (G.Forst.) C.Presl, *Reliq. Haenk.* 1: 32 (1825); *Lepidoneuron hirsutulum* (G.Forst.) Fée, *Mém. Foug.*, 5: 301 [*Gen. Filic.*] (1852); *Nephrolepis exaltata* (L.) Schott var. *hirsutula* (G.Forst.) Baker, *Syn. Fil.*, ed. 2, 301 (1874); *Aspidium exaltatum* (L.) Sw. var. *hirsutulum* (G.Forst.) F.M.Bailey, *Bot. Bull. Dept. Agric., Queensland* 17: 10 (1913)
Type: UNKNOWN, *Forster 278*, lectotype: BM [001048417*], designated by Nicolson & Fosberg (2004).
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10544*, BSIP!, TAIF [520501!] [520502!], TNM!
Note: This species was misidentified as *N. brownii* (Desv.) Hovenkamp & Miyam. in Chen et al. (2017a). *Nephrolepis hirsutula* differs from *N. brownii* by having dense rufous (vs. hyaline) rachis scales (Hovenkamp & Miyamoto, 2005).

Nephrolepis lauterbachii (Christ) Christ, *Bull. Herb. Boissier,* sér. 2, 1: 456 (1901). T,

E
Nephrolepis cordifolia (L.) C.Presl var. *lauterbachii* Christ, *Fl. Schutzgeb. Südsee* 118 (1901)
Type: PAPUA NEW GUINEA, *Lauterbach 578*, holotype: P [01410065*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11135*, BSIP!, TNM!

Nephrolepis obliterata (R.Br.) J.Sm., *J. Bot.* 4: 197 (1841). T, K
Nephrodium obliteratum R.Br., *Prodr.* 148 (1810); *Aspidium obliteratum* (R.Br.) Spreng., *Syst. Veg.,* ed. 16, 4(1): 99 (1827); *Arthropteris obliterata* (R.Br.) J. Sm., *Ferns Brit. For.* 163 (1866)
Type: AUSTRALIA, *Banks s.n.*, lectotype: BM [001048237*], designated by Field (2020); isolectotype: BM [001048238*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10455*, BSIP!, TAIF [520071!] [520072!], TNM!

LOMARIOPSIDACEAE Alston, *Taxon* 5(2): 25 (1956)
CYCLOPELTIS J. Sm., *Bot. Mag.* 72: 36 (1846)
Cyclopeltis novoguineensis Rosenst., *Repert. Spec. Nov. Regni Veg.* 10: 329 (1912). T, B
Type: PAPUA NEW GUINEA, *Bamler 46 = Filices novoguineenses exsicc. 86*, lectotype: S-P [3507*], designated here by Chen; isolectotypes: B [20 0040066*] [20 0040067], BM [001048658*] [001048659*] [001048660*], K [000235936*] [00235937*] [000235938] [000235939*], L [0051435*] [0051436*], NY [00128141*], P [01453526*] [01453527*], UC [352837*].
Voucher: Ranongga, 400–700 m, 16 Aug 2013, *Chen et al. SITW03085*, BSIP!, TAIF [445032!] [445033!], TNM!
Note: Many syntypes exist, and we selected the most complete one in S as lectotype. *Aspidium semicordatum* var. *biauriculatum* Baker, described from Makira, is a synonym of this species.

DRYOPOLYSTICHUM Copel., *Ann. Cryptog. Phytopathol.* 5: 125, t.4 [*Gen. Fil.*] (1947).
Dryopolystichum phaeostigma (Ces.) Copel., *Ann. Cryptog. Phytopathol.* 5: 126, t. 4 [*Gen. Fil.*] (1947). T, B
Aspidium phaeostigma Ces., *Rendiconto Reale Accad. Sci. Fis.* 16: 26, 29 (1877); *Dryopteris phaeostigma* (Ces.) C.Chr., *Index Filic.* 284 (1905)
Type: INDONESIA (Indonesian New Guinea), *Beccari s.n.*, holotype: FI [013621*]; isotype: K [000666125*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10443*, BSIP!, TAIF [499300!] [499301!] [499302!] [519931!] [519932!], TNM!
Note: Chen et al. (2017b) incorrectly cited a specimen collected from Andai (FI [013622*]) as the type. Based on the protologue, the type was collected from Monte Arfak a Putat.

LOMARIOPSIS Fée, *Mém. Foug.*, 2: 10 [*Hist. Acrostich.*] (1845)
Lomariopsis brackenridgei Carruth., *Fl. Vit.* 373 (1873). E, F
Stenochlaena brackenridgei (Carruth.) Underw., *Bull. Torrey Bot. Club* 33: 45, f.4 (1906)
Type: FIJI, *Seemann 711*, lectotype: K [001094241*], designated by Holttum (1966);

isolectotype: K [001094240*].
Voucher: Vella Lavella, 50–200 m, 25 Oct 2013, *Chen et al. SITW04992*, BSIP!, TAIF [462551!] [462552!] [462553!], TNM!

Lomariopsis oleandrifolia (Brack.) Mett. ex Kuhn, *Verh. K.K. Zool.-Bot. Ges. Wien* 19: 571 (1869). E, D
Stenochlaena oleandrifolia Brack., *U.S. Expl. Exped., Filic.* 16: 75 (1854)
Type: FIJI, *Wilkes Expl. Exped. s.n.*, holotype: US [00135396*] [00135397*].
Voucher: Rendova, 0–700 m, 28 Aug 2013, *Chen et al. SITW03449*, BSIP!, TAIF [448480!] [448481!], TNM!

TECTARIACEAE Panigrahi, *J. Orissa Bot. Soc.* 8: 41 (1986)
ARTHROPTERIS J.Sm., *Fl. Nov.-Zel.* 2: 43 (1854)
Arthropteris palisotii (Desv.) Alston, *Bol. Soc. Brot.*, sér. 2, 30: 6 (1956). E, T
Aspidium palisotii Desv., *Mag. Neuesten Entdeck. Gesammten Naturk. Ges. Naturf. Freunde Berlin* 5: 320 (1811)
Type: WEST AFRICA, *Palisot s.n.*, holotype: P [00483344*].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10515*, BSIP!, TAIF [498604!] [498605!] [498606!] [519870!] [519871!] [519872!], TNM!

POLYDICTYUM C. Presl, *Epimel. Bot.* 52 (1851 ['1849'])
Polydictyum menyanthidis (C.Presl) C.Presl, *Epimel. Bot.* 53 (1851 ['1849']). T, N
Aspidium menyanthidis C.Presl, *Reliq. Haenk.* 1: 28 (1825); *Cardiochlaena menyanthidis* (C.Presl) Fée, *Mém. Foug.,* 5: 315 [*Gen. Filic.*] (1852); *Sagenia menyanthidis* (C.Presl) T.Moore, *Index Fil.* 5: 96 (1858); *Nephrodium menyanthidis* (C.Presl) Baker, *Syn. Fil.* 297 (1868); *Dryopteris menyanthidis* (C.Presl) Kuntze, *Revis. Gen. Pl.* 2: 813 (1891); *Tectaria menyanthidis* (C.Presl) Copel., *Philipp. J. Sci., C.* 2: 414 (1907)
Type: PHILIPPINES (Luzon), *Haenke s.n.*, holotype: PRC [450256*] [450257*].
Voucher: Malaita, 150–350 m, 22 Jul 2015, *Chen et al. SITW07638*, BSIP!, TAIF [486638!], TNM!
Note: This species was recorded as *Tectaria menyanthidis* in Chen et al. (2017a). Recent phylogenetic studies have revealed that *T. menyanthidis* and allied species represent a distinct lineage (i.e., *Polydictyum*), which was resolved as the sister group of *Pteridrys* C.Chr. (Dong et al., 2018; Zhou et al., 2018).

TECTARIA Cav., *Anales Hist. Nat.* 1: 115 (1799)
Tectaria angulata (Willd.) Copel., *Sarawak Mus. J.* 2: 370 (1917). T, L
Polypodium angulatum Willd., *Sp. Pl.,* ed. 4, 5(1): 185 (1810); *Aspidium angulatum* (Willd.) J.Sm. ex Hook., *Sp. Fil.* 4: 44 (1862); *Dryopteris angulata* (Willd.) Kuntze, *Revis. Gen. Pl.* 2: 812 (1891)
Type: INDONESIA (Java), *Ventenat s.n.*, holotype: B-W [19641-010*].
Voucher: Malaita, 150–350 m, 22 Jul 2015, *Chen et al. SITW07629*, BSIP!, TAIF [486611!], TNM!

Tectaria aurita (Sw.) S.Chandra, *Kalikasan* 12: 157 (1983). T, N
Acrostichum auritum Sw., *J. Bot. (Schrader)* 1800(2): 12 (1801); *Polybotrya aurita* (Sw.) Blume, *Fl. Javae Fil.*, 15, t.1 (1828); *Stenosemia aurita* (Sw.) C.Presl, *Tent. Pterid.* 237, t.10, f.24 (1836)

Type: INDONESIA (Java), *Thunberg s.n.*, holotype: S-P [4817*].
Voucher: Malaita, 150–350 m, 22 Jul 2015, *Chen et al. SITW07632*, BSIP!, TAIF [486609!], TNM!

Tectaria bamleriana (Rosenst.) C.Chr., *Index Filic. Suppl. Tert.* 177 (1934). T, E
Aspidium bamlerianum Rosenst., *Repert. Spec. Nov. Regni Veg.* 10: 338 (1912)
Type: PAPUA NEW GUINEA (Morobe, Wareo Village), *Bamler K10*, lectotype: L, designated by Holttum (1991); isolectotype: S-P [597*].
Voucher: Isabel, 600–1000 m, 16 Jul 2014m *Chen et al. SITW05632*, TAIF!, TNM!
Note: The type was incorrectly cited as *Bamler W10* in the protologue.

Tectaria christovalensis (C.Chr.) Alston, *J. Bot.* 77: 290 (1939). T, B
Gymnogramma palmata Baker, *Syn. Fil.* 389 (1868) *non* Link, *Hort. Berol.* 2: 48 (1833); *Polypodium christovalense* C.Chr., *Index Filic.* 516 (1906); *Colysis christovalensis* (C.Chr.) Ching, *Sunyatsenia* 5: 261 (1940)
Type: SOLOMON ISLANDS (Makira), *Milne 502*, holotype: K [000603041*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10489*, BSIP!, TAIF [519947!], TNM!
Note: The type was incorrectly cited as *Milne 508* in the protologue.

Tectaria crenata Cav., *Descr. Pl.* 250 (1802), T, I
Sagenia crenata (Cav.) Hosok., *Trans. Nat. Hist. Soc. Formosa* 26: 72 (1936); *Aspidium crenatum* (Cav.) Ching, *Bull. Fan Mem. Inst. Biol.* 10: 237 (1941), *non* Sommerf., *Kongl. Vetensk. Acad. Handl.* 1834: 104 (1835)
Type: MARIANAS ISLANDS, *Nee s.n.*, holotype: MA [213019*] [213020-2*]; isotype: BM [001048597*].
Voucher: Vanikoro, 150 m, 28 Jul 2016, *Chen et al. SITW11094*, BSIP!, TNM!

Tectaria decurrens (C.Presl) Copel., *Leafl. Philipp. Bot.* 1: 234 (1907). T, S
Aspidium decurrens C.Presl, *Reliq. Haenk.* 1: 28 (1825); *Sagenia decurrens* (C.Presl) T.Moore, *Index Fil.* 89 (1858); *Acrostichum decurrens* (C.Presl) Benth., *Fl. Hongk.* 443 (1861); *Nephrodium decurrens* (C.Presl) Baker, *Syn. Fil.* 299 (1868); *Dryopteris decurrens* (C.Presl) Kuntze, *Revis. Gen. Pl.* 2: 812 (1891)
Type: PHILIPPINES (Luzon), *Haenke s.n.*, holotype: PRC [450242*].
Voucher: Vanikoro, 300 m, 22 Jul 2016, *Chen et al. SITW11067*, BSIP!, TNM!

Tectaria devexa (Kunze) Copel., *Philipp. J. Sci. 2: 415* (1907). T, S
Aspidium devexum Kunze, *Bot. Zeitung (Berlin)* 6: 259 (1848); *Dryopteris devexa* (Kunze) Kuntze, *Revis. Gen. Pl.* 2: 811 (1891); *Nephrodium devexum* (Kunze) Makino, *Bot. Mag. (Tokyo)* 10: 56 (1896); *Pleocnemia devexa* (Kunze) Alderw., *Malayan Ferns* 174, 811 (1909); *Ctenitopsis devexa* (Kunze) Ching & Chu H.Wang, *Acta Phytotax. Sin.* 9(4): 369 (1964)
Type: INDONESIA (Java), *Zollinger 2717*, holotype: LZ, lost; lectotype: B [20 0030298*], designated here by Dong; isolectotypes: BM!, L [0931044*].
Voucher: Guadalcanal, 400–800 m, *Chen et al. SITW11130*, BSIP!, IBSC!, TAIF [498954!], TNM!

Tectaria durvillei (Bory) Holttum, *Fl. Males., ser. 2, Pterid.* 2(1): 67 (1991). T, B

Aspidium durvillaei Bory, *Dup. Voy. Bot.* 1: 266 (1828)
Type: INDONESIA (Indonesian New Guinea, Waigeou Island), *d'Urville s.n.*, holotype: P [00644711*]; isotype: K [000362472*].
Voucher: Guadalcanal, 50–200 m, 23 Jul 2014, *Chen et al. SITW05691*, BSIP!, TAIF [472942!] [473054!] [473055!] [473056!] [473057!], TNM!

Tectaria gymnocarpa Copel., *Philipp. J. Sci., C.* 9: 4 (1914). T, B
Type: PAPUA NEW GUINEA, *King 401*, holotype: MICH [1191045*].
Voucher: Nendo, 10–100 m, 13 Jun 2016, *Chen et al. SITW10554*, BSIP!, TAIF [498580!] [498581!] [520534!] [520535!], TNM!
Note: This species was recorded as *Tectaria ferruginea* (Mett.) Copel. in Chen et al. (2017a), which is a later homonym of *T. ferruginea* Cav. and therefore illegitimate.

Tectaria hederifolia (Baker) C.Chr., *Index Filic. Suppl. Tert.* 180 (1934). T, A
Nephrodium hederifolium Baker, *J. Linn. Soc., Bot.* 19: 295 (1882)
Type: SOLOMON ISLANDS (Makira), *Comins 59*, holotype: K [000636178*].
Note: Endemic but insufficiently known only by the type.

Tectaria hookeri Brownlie, *Nova Hedwigia Beih.* 55: 287 (1977). T, D
Nephrodium milnei Hook, *Sec. Cent. Ferns*, t. 62 (1861)
Type: FIJI (Naviti Levu), *Milne s.n.*, holotype: K [000636180*] [000636181*].
Voucher: Makira, 243 m [800 ft], 1 Aug 1965, *Braithwaite RSS 4243*, L [3612789*].
Note: *Tectaria hookeri* was a replacement name for *Nephrodium milnei* in *Tectaria*, as *T. milnei* (Hook.) Copel. had already existed since 1929. Newly recorded for the Solomon Islands.

Tectaria isomorpha Holttum, *Dansk Bot. Ark.* 25: 49 (1967). T, B
Type: PAPUA NEW GUINEA, *Dissing & Olsen 2369*, holotype: C; isotype: K [000375251*].
Voucher: Malaita, 500 m, 31 Jul 2015, *Chang et al. SITW08455*, BSIP!, TAIF [495050!], TNM!
Note: Newly recorded from the Solomon Islands. However, the scale colour of plants from the Solomon Islands is different from that of the type (glossy blackish vs. dull brownish). Further study is needed to confirm whether the two populations are conspecific.

Tectaria latifolia (G.Forst.) Copel., *Philipp. J. Sci., C.* 2: 410 (1907). T, I
Polypodium latifolium G.Forst., *Fl. Ins. Austr.* 83 (1786): *Aspidium latifolium* (G.Forst.) J. Sm., *J. Bot.* 3: 410 (1841), *non A. latifolium* C. Presl, *Reliq. Haenk.* 1: 30 (1825); *Aspidium forsteri* Kunze, *Bot. Zeitung (Berlin)* 4: 462 (1846)
Type: POLYNESIA (without specific locality, probably Austral Islands), *Forster s.n.*, lectotype: BM [001048491*], designated by Nicolson & Fosberg (2004); isolectotypes: B-W [19714-010*], GOET [012820*], LE [00008746*] [00008747*], S [P-10258*].
Voucher: Nendo, 10 m, 4 Jul 2016, *Chen et al. SITW11095*, BSIP!, TAIF [498961!] [498962!] [498963!], TNM!
Note: *Tectaria latifolia* as treated here is a species complex and includes *T. melanocaulis* (Blume) Copel. sensu Chen et al. (2017a) and *T. tahitensis* Maxon sensu Chen et al. (2017a). Our unpublished phylogenetic analyses resolved that "*T. melanocaulis*" from

Solomon Islands is in a distinct lineage from the true *T. melanocaulis* from Sumatra (type locality of this species) and identified three well supported clades within the *T. latifolia* complex. The morphological characters that have been used to distinguish *T. latifolia* and morphologically similar species seem to be plastic, e.g., laminar dissection, frond size, and stipe colour (black vs. castaneous). Species boundaries within the *T. latifolia* complex are currently unclear, and further studies focusing on morphological variation are badly needed.

Tectaria nayarii Mazumdar, *Phytotaxa* 158(3): 298 (2014). T, N
Stenosemia pinnata Copel., *Philipp. J. Sci.* 1(Suppl. 2): 146 (1906); *Heterogonium pinnatum* (Copel.) Holttum, *Sarawak Mus. J.* 5: 163 (1949)
Type: PHILIPPINES (Mindanao), *Copeland 1601*, holotype: MICH [1191022*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11588*, BSIP!, TNM!
Note: *Tectaria nayarii* is a replacement name for *Stenosemia pinnata* in *Tectaria*, as *T. pinnata* (C.Chr.) R.M.Tryon & A.F.Tryon pre-empts it.

Tectaria profereoides (Christ) S.Y.Dong, *Phytotaxa* 178: 226 (2014). T, E
Aspidium profereoides Christ, *Philipp. J. Sci., C.* 2: 158 (1907); *Pleocnemia profereoides* (Christ) Alderw., *Malayan Ferns* 812 (1909); *Heterogonium profereoides* (Christ) Copel., *Univ. Calif. Publ. Bot.* 16: 61 (1929)
Type: PHILIPPINES (Mindanao), *Copeland 1467A*, holotype: MICH [1190040!].
Voucher: Kolombangara, 600–700 m, 5 Nov 2013, *Chen et al. SITW04050*, BSIP!, TAIF [460021!] [460021!] [460021!], TNM!
Note: The voucher was misidentified as *T. aspidioides* (C.Presl) Copel. in Chen et al. (2017a). *Tectaria profereoides* and associated species were previously placed in a separate genus, *Heterogonium* C.Presl. However, *Heterogonium* appears to be non-monophyletic in phylogenetic analyses (Ding et al., 2014) and thus was subsumed in *Tectaria* (Dong, 2014). *Tectaria profereoides* can be distinguished from *T. aspidioides* by having only one row of costal areoles (versus two or more) and the width of the middle pinnae (2–3 versus 3–5 cm).

Tectaria repanda (Willd.) Holttum, *Fl. Males., ser. 2, Pterid.* 2(1): 80 (1991). T, N
Aspidium repandum Willd., *Sp. Pl.,* ed. 4, 5(1): 216 (1810); *Bathmium repandum* (Willd.) Fée, *Mém. Foug.,* 5: 287 [*Gen. Filic.*] (1852); *Sagenia repanda* (Willd.) T.Moore, *Index Fil.* 5: 102 (1858) *non* C.Presl, *Epimel. Bot.* 59 (1851 [‘1849’]); *Dryopteris repanda* (Willd.) Kuntze, *Revis. Gen. Pl.* 2: 813 (1891)
Type: PHILIPPINES (Bicol), *Willdenow s.n.*, holotype: B-W [19734-011*] [19734-012*].
Voucher: Guadalcanal, 50–150 m, 11 Jul 2016, *Chen et al. SITW11112*, BSIP!, TNM!

***Tectaria* sp. 1.** T
Voucher: Guadalcanal, 50–200 m, 23 Jul 2014, *Chen et al. SITW05693*, BSIP!, TAIF [472945!] [472946!] [472947!], TNM!
Note: The voucher is morphologically very distinct and represents an undescribed species. It is characterised by its 3- to 4-pinnate fronds, free veins, and broad appressed scales on the abaxial surfaces of the rachises and costae (Chen et al., 2017a: 435). We have not found a comparable species across Asia, Malesia and Pacific islands. Our phylogenetic analyses of chloroplast DNA sequences confirmed its position in the

Ctenitopsis group (Clade III) of *Tectaria*, and indicated it is closely allied to *T. psomiocarpa* S.Y.Dong (Dong et al., 2018). The latter is endemic to the Philippines and differs in its strongly dimorphic fronds, with fertile pinnae contracted and moniliform in shape. A detailed description of this new species will be presented in a separate article.

***Tectaria* sp. 2.** T
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11142*, BSIP!, IBSC!, TAIF [498948!] [498949!] [498950!] [498951!] [498952!] [498953!], TNM!
Note: Based on our unpublished morphological comparisons and phylogenetic analyses, we conclude that the voucher represents an undescribed species. This new species is a member of the *T. latifolia* complex but can be readily distinguished from *T. latifolia* and other allied taxa by its broad stipe scales (2.5–3 mm vs. 0.5–1 mm wide) and the light-stramineous (green when living) colour of the stipe and rachis (vs. blackish or castaneous) (Chen et al., 2017a: 436). Four samples of this species were resolved in a well-supported subclade within the *T. latifolia* clade. Detailed results and formal establishment of this new species will be presented in a separate article.

***Tectaria* sp. 3.** T
Voucher: Kolombangara, 300–600 m, 17 Oct 2013, *Chen et al. SITW04945*, BSIP!, IBSC!, TAIF [464217!] [464218!], TNM!
Note: The voucher represents an undescribed species, to be published in a separate article. It is morphologically similar to *T. gymnocarpa* (formerly misnamed as *T. ferruginea*) in frond shape and dissection and the pattern of venation. However, this species differs in its lamina being less dissected (1-pinnate-pinnatifid to 2-pinnate at base vs. 2- to 3-pinnate), veins more fully anastomosing, and sori indusiate (vs. exindusiate) (Chen et al., 2017a: 437). In our unpublished phylogenetic analysis, this new species was resolved as sister to *T. melanocaulis* in the core *Tectaria* (Clade IV), being rather distant from *T. gymnocarpa* in *Ctenitopsis* group (Clade III) (Dong et al., 2018).

***Tectaria* sp. 4.** R
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11129*, BSIP! IBSC!, TNM!
Note: The voucher represents an undescribed species, to be published in a separate article. It is morphologically unique in having simple or trifoliate fronds and sori distributed in 2 rows between the main lateral veins (Chen et al., 2017a: 438) as compared with all other *Tectaria* species in the Solomon Islands and nearby archipelagos (New Guinea, New Caledonia and Vanuatu). Our unpublished phylogenetic analysis of *Tectaria* resolved this species to be sister to the *T. angulata–T. christovalensis* clade.

OLEANDRACEAE Ching ex Pic.Serm., *Webbia* 20: 745 (1965)
OLEANDRA Cav., *Anales Hist. Nat.* 1: 115 (1799)
Oleandra neriiformis Cav., *Anales Hist. Nat.* 1: 115 (1799). C, N
Aspidium neriiforme (Cav.) Sw., *Syn. Fil.* 42, 237 (1806)
Type: PHILIPPINES (Mauban), *Née s.n.*, holotype: MA [476029*]; isotypes: BM [001048293*], MA [476030*], S-P [14697*].
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10572*, BSIP!, TAIF [520561!] [520562!] [519960!], TNM!

Oleandra sibbaldii Grev., *Ann. Nat. Hist. II*, 1: 327 (1848). E, N
Oleandra cumingii J.Sm. var. *sibbaldii* Baker, *Syn. Fil*. 303 (1868)
Type: FRENCH POLYNESIA (Tahiti), *Sibbald s.n*., holotype: E [00417634*]; isotypes: BM [001048283*], E [00417635*].
Voucher: Guadalcanal, 1706 m [5600 ft], 28 Oct 1965, *Braithwaite RSS 4676*, L [0119256*].

Oleandra werneri Rosenst., *Repert. Spec. Nov. Regni Veg*. 5: 40 (1908). C, N
Type: PAPUA NEW GUINEA, *Werner 12 = Filices novoguineenses exsicc. 28*, lectotype: L [0397376*], designated by Hovenkamp & Ho (2012); isolectotypes: B [20 0154675*], S-P [7288*], UC [391405*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW06936*, BSIP!, TAIF [482798!], TNM!
Note: *Oleandra dimorpha* Copel., described from Makira, is a synonym of this species.

DAVALLIACEAE M.R.Schomb., *Reis. Br.-Guiana* 3: 883 (1849)
DAVALLIA Sm., *Mém, Acad. Roy. Sci. (Turin)* 5: 414, t.9, f.6 (1793).
Davallia denticulata (Burm.f.) Mett. ex Kuhn var. ***elata*** (G.Forst.) Mett. ex Kuhn, *Miq., Ann. Mus. Bot. Lugd.-Bat.* 4: 288 (1869). E, N
Trichomanes elatum G.Forst., *Fl. Ins. Austr*. 85 (1786); *Wibelia elata* (G.Forst.) Bernh., *J. Bot. (Schrader)* 1800(2): 122, t.1, f.2 (1801); *Davallia elata* (G.Forst.) Sw., *Syn. Fil*. 131 (1806); *Humata elata* (G.Forst.) Desv., *Mem. Soc. Linn. Paris* 6, 2: 325 (1827); *Parestia elata* (G.Forst.) C.Presl, *Epimel. Bot.* 100 (1851 ['1849'])
Type: PACIFIC ISLANDS, *Forster 309*, lectotype: BM [001048190*], designated by Nooteboom (1994).
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10475*, BSIP!, TAIF [519948!], TNM!

Davallia graeffei Luerss., *Fil. Graeff*. 211, t.18 (1871). E, C
Type: SAMOA (Savaii), *Graeffe 227*, holotype: P [01409835*].
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10594*, BSIP!, TAIF [520513!] [520550!] [520552!], TNM!
Note: This species was unidentified in Chen et al. (2017a: 455) and newly recorded here from the Solomon Islands.

Davallia heterophylla Sm., *Mém, Acad. Roy. Sci. (Turin)* 5: 415 (1793). E, N
Humata heterophylla (Sm.) Desv., *Mém. Soc. Linn. Paris* 6(3): 323 (1827)
Type: INDONESIA (Sumatra), *Miller 1778*, lectotype: BM [001045414*], designated by Nooteboom (1994).
Voucher: Makira, 910 m, 1 Jul 2015, *Chen et al. SITW06863*, BSIP!, TAIF [482816!], TNM!, VT [202939!].

Davallia kinabaluensis (Copel.) C.W.Chen, *Sol Amazing* 447 (2017). E, E
Humata kinabaluensis Copel., *Philipp. J. Sci., C.* 12: 48 (1917)
Type: MALAYSIA (Sabah), *Topping 1745*, holotype: PNH, destroyed; lectotype: GH [00936565*], designated by Nooteboom (1994); isolectotypes: MICH [1190618*], US [00135421*].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07564*, BSIP!, TAIF

[486645!], TNM!
Note: The holotype in PNH was destroyed, and the only specimen cited by Nooteboom (1994) is that from A (now integrated with GH). This was here treated as an effective lectotypification by Nooteboom, in accordance with ICN Art. 7.11 (Turland et al. 2018).

Davallia leptocarpa Mett. ex Kuhn, *Linnaea* 36: 143 (1869). E, C
Type: VANUATU, *MacGillivray 56*, lectotype: K [000061869*], designated by Nooteboom (1994); isolectotypes: BM [001045945*] [001045946*], K [000061868*], L [0931029*] [0931030*], P [00630918*] [00630919*] [00630920*] [04022113*], S-P [3968*].
Voucher: Guadalcanal, 800–1000 m, 16 Sep 2015, *Chen et al. SITW09658*, BSIP!, TNM!
Note: This species was previously known only from Polynesia and Vanuatu, and was here newly recorded from the Solomon Islands.

Davallia pectinata Sm., *Mém, Acad. Roy. Sci. (Turin)* 5: 415 (1793). E, S
Type: FRENCH POLYNESIA (Tahiti), *Hurloch s.n.*, lectotype: LINN [1635.19-2], designated by Field (2020).
Voucher: Rendova, 0–700 m, 28 Aug 2013, *Chen et al. SITW03458*, BSIP!, TAIF [448576!], TNM!

Davallia pentaphylla Blume, *Enum. Pl. Javae* 2: 232 (1828). E, N
Stenolobus pentaphyllus (Blume) C.Presl, *Epimel. Bot.* 99 (1851 [‘1849’]); *Scyphularia pentaphylla* (Blume) Fée, *Mém. Foug.* 5: 325, t. 26B, f. 1 [*Gen. Filic.*] (1852)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L [0051464*], designated by Nooteboom (1994); isolectotype: K [000228382*].
Voucher: Rendova, 700–1000 m, 26 Aug 2013, *Chen et al. SITW03387*, BSIP!, TAIF [448707!], TNM!

Davallia pubescens C.W.Chen, *Sol Amazing* 450 (2017). E, E
Leucostegia hirsuta J.Sm., *J. Bot.* 3: 416 (1841); *Microlepia hirsuta* (J.Sm.) C.Presl, *Epimel. Bot.* 97 (1851 [‘1849’]); *Davallodes hirsutum* (J.Sm.) Copel., *Philipp. J. Sci., C.* 33 (1908); *Davallia hirsuta* (J.Sm.) Alderw., *Malayan Ferns* 299 (1909), *non* Sw., *J. Bot. (Schrader)* 1800(2): 87 (1801)
Type: PHILIPPINES (Luzon), *Cuming 174*, lectotype: BM [001045937*], designated here by Chen; isolectotypes: BM [001045939*], FI [004192*], K [000490817*], L [0537142*].
Voucher: Kolombangara, 600–700 m, 5 Aug 2013, *Chen et al. SITW02985*, BSIP!, TAIF [445128!], TNM!
Note: The transfer of *Leucostegia hirsuta* to *Davallia* is blocked by *Davallia hirsuta* Sw., therefore a new name was provided by Chen et al. (2017a). We selected the sheet from John Smith’s herbarium in BM as lectotype.

Davallia pusilla Mett., *Ann. Sci. Nat., Bot.,* sér. 4, 15: 79 (1861). E, N
Humata pusilla (Mett.) Carruth., *Fl. Vit.* 335 (1873); *Pachypleuria pusilla* (Mett.) M.Kato, *J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot.* 13(5): 573 (1985)
Type: NEW CALEDONIA, *Vieillard 1627*, lectotype: P [00637437*], designated by Nooteboom (1994); isolectotypes: BM [001045970*], BR [0000013305925*] [0000013305932*], K [000061852*] [000061853*], P [00630909*] [00637438*]

[00637439*].
Voucher: Vanikoro, 20–250 m, 20 Jun 2016, *Chen et al. SITW11033*, BSIP!, TNM!

Davallia sessilifolia Blume, *Enum. Pl. Javae* 2: 231 (1828). E, N
Humata sessilifolia (Blume) Mett., *Fil. Hort. Bot. Lips*. 102 (1856); *Pachypleuria sessilifolia* (Blume) C.Presl, *Epimel. Bot*. 98 (1851 ['1849'])
Type: INDONESIA (Java), *Korthals s.n*., lectotype: L [0931025*], designated by Nooteboom (1994).
Voucher: Guadalcanal, 300–1300 m, 23 Jul 2016, *Chen et al. SITW11601*, BSIP!, TNM!
Note: Nooteboom (1994) erroneously cited the collectors of the type as *Kuhl & van Hasselt*. A specimen in LE [00008200*] has the same locality "Salak" as the lectotype but is without collector; this might be an isolectotype.

Davallia solida (G.Forst.) Sw., *J. Bot. (Schrader)* 1800(2): 87 (1801). E, S
Trichomanes solidum G.Forst., *Fl. Ins. Austr*. 86 (1786)
Type: PACIFIC ISLANDS, *Forster 308*, lectotype: BM [001048399*], designated by Nooteboom (1994).
Voucher: San Jorge, 20–450 m, 6 Jun 2016, *Chen et al. SITW10500*, BSIP!, TAIF [519919!], TNM!

Davallia sp. E
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04925*, BSIP!, TAIF [464209!] [464210!], TNM!
Note: Chen et al. (2017a) misapplied the name *D. serrata* Willd. to this species with the intention of using *Humata serrata* Brack. instead. However, Brackenridge's name is a later homonym of *H. serrata* (Willd.) Desv. and thus illegitimate; a new name is needed. Considering that this is a member of a species complex that has a complex evolutionary history and a difficult taxonomy (Chen et al., 2014), we prefer not to propose a new name for *H. serrata* Brack. because there is insufficient evidence that it warrants recognition.

POLYPODIACEAE J.Presl & C.Presl, *Delic. Prag*. 159 (1822)
ACROSORUS Copel., *Philipp. J. Sci*. 1(Suppl. 2): 158 (1906)
Acrosorus reineckei (Christ) Copel., *Philipp. J. Sci., C*. 2: 136 (1907). E, D
Davallia reineckei Christ, *Bot. Jahrb. Syst*. 23(3): 341, t.5, f.1 (1896); *Prosaptia reineckei* (Christ) Christ, *Nachtr. Fl. Schutzgeb. Südsee* 41 (1905); *Polypodium reineckei* (Christ) C.Chr., *Index Filic. Suppl. Prél.* 28 (1917); *Grammitis reineckei* (Christ) Christenh., *Global Fl*. 4: 48 (2018)
Type: SAMOA, *Reinecke 186*, lectotype: P [01501880*], designated here by Parris; isolectotypes: B [20 0097609!] [20 0097610!], BM [001039882!], BO!, E [00194172!], K [001044304!], MICH [1191151*], P [01501881*], US [00134742!], W.
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04938*, BSIP!, TAIF [463822!], TNM!
Note: We selected the more complete sheet in P, with Christ's annotation, as lectotype.

ARCHIGRAMMITIS Parris, *Fern Gaz*. 19(4): 135 (2013)
Archigrammitis demissa (Parris) Parris, *Fern Gaz*. 19(4): 136 (2013). E, E
Grammitis demissa Parris, *Blumea* 29(1): 39 (1983)
Type: PAPUA NEW GUINEA, *Stevens LAE 58480*, holotype: K [000557561!]; isotypes:

A, BRI-AQ [0365714!], CANB, E [00194213!], L [0051648!], LAE, M, NSW!
Voucher: New Georgia, 400–520 m, 27 Sep 2012, *Chen et al. SITW00598*, BSIP!, TAIF [421075!], TNM!
Note: Newly recorded from the Solomon Islands.

Archigrammitis solomonensis Parris, *sp. nov*. E, A
Type: see section describing new species.
Note: Endemic and known only from the type collection.

CALYMMODON C.Presl, *Tent. Pterid*. 203 (1836)
Calymmodon furcatus Parris, *sp. nov*. E, A
Type: see section describing new species.
Note: This species was illustrated in Chen et al. (2017a) as *Calymmodon* sp. 3. It is endemic and known only from the type collection.

Calymmodon gracilis (Fée) Copel., *Philipp. J. Sci*. 34: 266 (1927). E, P
Plectopteris gracilis Fée, *Mém. Foug*. 5: 230, t. 19B [*Gen. Filic*.] (1852)
Type: PHILIPPINES, *Cuming 206*, holotype: RB [00663742*]; isotypes: B [20 0097451!] [20 0097452!], BM [000053091!] [000053105!], CGE!, E [00194053!] [00194055!] [00194062], K [000501102!], L!, OXF!, P.
Voucher: Guadalcanal, 1706 m [5600 ft], 28 Oct 1965, *Braithwaite RSS 4679*, K [001044310!].

Calymmodon solomonensis Parris, *sp. nov*. E, A
Type: see section describing new species.
Note: Endemic and known only from the type collection.

Calymmodon subgracilis Parris, *sp. nov*. E, A
Type: see section describing new species.
Note: This species was illustrated in Chen et al. (2017a) as *Calymmodon* sp. 1, endemic.

Calymmodon subtilis Parris, *sp. nov*. E, B
Type: see section describing new species.
Note: This species was illustrated in Chen et al. (2017a) as *Calymmodon* sp. 2.

CHRYSOGRAMMITIS Parris, *Kew Bull*. 53(4): 909 (1998)
Chrysogrammitis musgraviana (Baker) Parris, *Kew Bull*. 53: (1998). E, N
Polypodium musgravianum Baker, *J. Bot*. 108 (1890); *Xiphopteris musgraviana* (Baker) Parris, *Kew Bull*. 41(1): 69 (1986); *Grammitis musgraviana* (Baker) Christenh., *Global Fl*. 4: 47 (2018)
Type: PAPUA NEW GUINEA, *MacGregor s.n*., holotype: K [000604061!].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11678*, BSIP!, TNM!

CTENOPTERELLA Parris, *Gard. Bull. Singapore* 58(2): 234 (2007)
Ctenopterella blechnoides (Grev.) Parris, *Gard. Bull. Singapore* 58(2): 235 (2007). E, S
Grammitis blechnoides Grev., *Ann. Mag. Nat. Hist. II*, 1: 320, t. 17 (1848); *Polypodium blechnoides* (Grev.) Hook., *Sp. Fil*. 4: 180 (1862); *Cryptosorus blechnoides* (Grev.) J.Sm., *Hist. Fil*. 87 (1875); *Ctenopteris blechnoides* (Grev.) W.H.Wagner & Grether, *Univ. Calif.*

Publ. Bot. 23: 61 (1948)
Type: FRENCH POLYNESIA (Society Islands), *Sibbald s.n.*, lectotype: E [00163920!], designated by Parris (2007); isolectotype: E [00163921!].
Voucher: San Jorge, 20–450 m, 6 Jun 2016, *Chen et al. SITW10510*, BSIP!, TAIF [498608!] [519875!], TNM!

Ctenopterella pacifica Parris, *sp. nov*. E, D
Ctenopteris pacifica Parris, *ined*., *Holttum Mem. Vol*. 81–90 (1997)
Type: see section describing new species.
Note: This species was illustrated in Chen et al. (2017a) as *Ctenopterella* sp.

DASYGRAMMITIS Parris, *Gard. Bull. Singapore* 58(2): 238 (2007)
Dasygrammitis brevivenosa (Alderw.) Parris, *Gard. Bull. Singapore* 58(2): 239 (2007). E, N
Polypodium brevivenosum Alderw., *Bull. Jard. Bot. Buitenzorg*, ser. 2, 28: 40 (1918); *Ctenopteris brevivenosa* (Alderw.) Holttum, *Rev. Fl. Mal*. 2: 228 (1955); *Grammitis brevivenosa* (Alderw.) Christenh., *Global Fl*. 4: 42 (2018)
Type: INDONESIA (Sumatra), *Brooks 299.S*, holotype: BO [1347974!].
Voucher: Guadalcanal, 2133 m [7000 ft], 27 Oct 1965, *Braithwaite RSS 4666*, BSIP!, K!, L!

DRYNARIA (Bory) J.Sm., *J. Bot*. 4: 60 (1841), *nom. cons.*
Note: A phylogenetic study by Janssen & Schneider (2005) showed that *Drynaria* was paraphyletic with regard to *Aglaomorpha*, with the latter having priority at generic level. Christenhusz & Schneider (2012) submitted a proposal to conserve *Drynaria* over *Aglaomorpha* and it was subsequently approved by the Nomenclature Committee for Vascular Plants (Wilson 2016). Thus, all species of *Aglaomorpha* in Chen et al. (2017a) are now subsumed in *Drynaria*.

Drynaria drynarioides (Hook.) Christenh., *Phytotaxa* 230(3): 299 (2015). E, N
Acrostichum drynarioides Hook., *Sp. Fil.* 5: 282 (1864); *Dryostachyum drynarioides* (Hook.) Kuhn, *Ann. Mus. Bot. Lugd.-Bat*. 4: 296 (1869); *Photinopteris drynarioides* (Hook.) Bedd., *Handb. Ferns Brit. Ind., t*. 325 (1869); *Polypodium drynarioides* (Hook.) Christ, *Farnkr*. 117 (1897), *non* Gris., *Abh. Ges. Wiss. Gottingen* 7: 284 (1857); *Merinthosorus drynarioides* (Hook.) Copel., *Philipp. J. Sci., C.* 6: 92 (1911); *Aglaomorpha drynarioides* (Hook.) M.C.Roos, *Blumea* 31(1): 153 (1985)
Type: MALAYSIA (Peninsular Malaysia, Penang), *Norris s.n*., holotype: K [000660915*] [000660916*]; isotype: B [20 0143705*].
Voucher: Tetepare, 0–200 m, 24 Aug 2013, *Chen et al. SITW03358*, BSIP!, TAIF [448697!], TNM!

Drynaria heraclea (Kunze) T.Moore, *Index Fil.* 2: 346 (1862). E, L
Polypodium heracleum Kunze, *Bot. Zeitung (Berlin)* 6: 117 (1848); *Pleopeltis heraclea* (Kunze) Alderw., *Bull. Dépt. Agric. Indes. Néerl*. 27: 11 (1909); *Aglaomorpha heraclea* (Kunze) Copel., *Univ. Calif. Publ. Bot.* 16: 117 (1929); *Drynariopsis heraclea* (Kunze) Ching, *Sunyatsenia* 5: 262 (1940)
Type: INDONESIA (Java), *Zollinger 977*, holotype: B.
Voucher: Makira, 910 m, 1 Jul 2015, *Chen et al. SITW06903*, BSIP!, TAIF [482586!],

TNM!, VT [203010!].
Drynaria parkinsonii (Baker) Diels, *Fl. Schutzgeb. Südsee* 143 (1901). E, E
Polypodium parkinsonii Baker, *Ann. Bot. (Oxford)* 5: 481 (1891); *Aglaomorpha parkinsonii* (Baker) Parris & M.C.Roos, *Blumea* 31(1): 153 (1985)
Type: PAPUA NEW GUINEA, *Parkinson s.n.*, holotype: K [000856754*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11173*, BSIP!, TNM!

Drynaria rigidula (Sw.) Bedd., *Ferns Brit. Ind.* 3: pl. 314 (1869). E, S
Polypodium rigidulum Sw., *J. Bot. (Schrader)* 1800(2): 26 (1801); *Goniophlebium rigidulum* (Sw.) T.Moore, *Index Fil.* 396 (1862); *Aglaomorpha rigidula* (Sw.) Hovenkamp & S.Linds., *Gard. Bull. Singapore* 69(1): 153 (2017)
Type: INDONESIA (Java), *Thunberg s.n.*, lectotype: UPS-THUNB [24565*], designated by Lindsay et al. (2017).
Voucher: Guadalcanal, 50–300 m, 13 Jul 2016, *Chen et al. SITW11118*, BSIP!, TNM!

Drynaria sparsisora (Desv.) T.Moore, *Index Fil.* 348 (1862). E, O
Polypodium sparsisorum Desv., *Mag. Neuesten Entdeck. Gesammten Naturk. Ges. Naturf. Freunde Berlin* 5: 315 (1811); *Aglaomorpha sparsisora* (Desv.) Hovenkamp & S.Linds., *Gard. Bull. Singapore* 69(1): 153 (2017)
Type: PAPUA NEW GUINEA (Central Province), *Johns 11056*, neotype: SING [0195508*], designated by Lindsay et al. (2017); isoneotypes: BRI, BRIT, K, L, LAE, UPNG.
Voucher: Guadalcanal, 30–70 m, 14 Aug 2012, *Chen et al. SITW00103*, BSIP!, TAIF [417170!], TNM!

GONIOPHLEBIUM (Blume) C.Presl, *Tent. Pterid.* 185 (1836)
Goniophlebium demersum (Brause) Rödl-Linder, *Blumea* 34(2): 378 (1990). E, E
Polypodium demersum Brause, *Bot. Jahrb. Syst.* 49(1): 44 (1912)
Type: PAPUA NEW GUINEA, *Schultze 33*, holotype: B?; isotype: BM [001039835*].
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04914*, BSIP!, TAIF [464204!] [464205!], TNM!

Goniophlebium percussum (Cav.) W.H.Wagner & Grether, *Occas. Pap. Bernice Pauahi Bishop Mus.* 19: 88 (1948). E, M
Cyathea percussa Cav., *Descr. Pl.* 548 (1803); *Schellolepis percussa* (Cav.) Pic.Serm., *Webbia* 28: 470 (1973)
Type: MARIANA ISLANDS (Guam), *Nee s.n.*, holotype: MA [475601*]; isotype: BM [001039823*].
Voucher: Rennell, 10 m, 5 Sep 1990, *Glenny 2574*, BSIP [20283!], WELT [P016730!].

Goniophlebium persicifolium (Desv.) Bedd., *Suppl. Ferns Brit. Ind.* 21 (1876). E, R
Polypodium persicifolium Desv., *Mag. Neuesten Entdeck. Gesammten Naturk. Ges. Naturf. Freunde Berlin* 5: 316 (1811); *Schellolepis persicifolia* (Desv.) Pic.Serm., *Webbia* 28: 470 (1973)
Type: INDONESIA (Java), *s.c., s.n.*, holotype: P [01525193*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11656*, BSIP!, TNM!

Goniophlebium serratifolium Brack., *U.S. Expl. Exped., Filic.* 16: 35 (1854). E, D

Polypodium subauriculatum Blume var. *serratifolium* (Brack.) Hook., *Sp. Fil.* 5: 33 (1864); *Polypodium serratifolium* (Brack.) Diels, *Nat. Pflanzenfam.* 1(4): 312 (1899)
Type: FIJI, *Wilkes Explor. Exped. 12*, holotype: US [00134696*]; isotype: MICH [1190545*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11150*, BSIP!, TAIF [498946!] [498947!], TNM!

Goniophlebium subauriculatum (Blume) C.Presl, *Tent. Pterid.* 186 (1836). E, S
Polypodium subauriculatum Blume, *Enum. Pl. Javae* 2: 133 (1828); *Schellolepis subauriculata* J.Sm., *Ferns Brit. For.* 82 (1866)
Type: INDONESIA (Java), *Blume 130*, lectotype: L [980.286-630], designated by Rödl-Linder (1990); isolectotype: LE [00008798*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11152*, BSIP!, TNM!

LECANOPTERIS Reinw. ex Blume, *Enum. Pl. Javae* 2: 120 (1828)
Lecanopteris linguiformis (Mett.) Perrie & Brownsey, *Blume* 66: 246 (2021). E, N
Polypodium linguiforme Mett., *Ann. Mus. Bot. Lugd.-Bat.* 2: 228 (1866); *Pleopeltis linguiformis* (Mett.) Alderw., *Bull. Dépt. Agric. Indes Néerl.* 27: 6 (1909); *Microsorum linguiforme* (Mett.) Copel., *Univ. Calif. Publ. Bot.* 16: 116 (1929); *Dendroconche linguiforme* (Mett.) Testo, Sundue & A.R.Field, *Syst. Bot.* 44: 11 (2019)
Type: INDONESIA (Indonesian New Guinea), *Zippelius s.n.*, lectotype: L [0051905*], designated by Bosman (1991).
Voucher: Rendova, 0–700 m, 28 Aug 2013, *Chen et al. SITW03499*, BSIP!, TAIF [448538!], TNM!
Note: This species was placed in *Microsorum* in Chen et al. (2017a). Testo et al. (2019) proposed a new genus *Dendroconche* to accommodate the species but here we followed the expanded *Lecanopteris* of Perrie et al. (2021) which included *Dendroconche*.

Lecanopteris sinuosa (Wall. ex Hook.) Copel., *Ann. Cryptog. Phytopathol.* 5: 205 [*Gen. Fil.*] (1947). E, M
Polypodium sinuosum Wall., *Num. List no.* 2231 (1829), *nom. nud.*; *Polypodium sinuosum* Wall. ex Hook., *Sp. Fil.* 5: 61, *t.* 284 (1863); *Pleopeltis sinuosa* (Wall. ex Hook.) Bedd., *Handb. Ferns Brit. Ind.*, *t.* 8 (1866); *Phymatodes sinuosa* (Wall. ex Hook.) J.Sm., *Ferns Brit. For.*, ed. *2,* 296 (1877); *Myrmecophila sinuosa* (Wall. ex Hook.) Nakai ex H.Ito, *J. Jap. Bot.* 11: 98 (1935); *Myrmecopteris sinuosa* (Wall. ex Hook.) Pic.Serm., *Webbia* 31(1): 240 (1977)
Type: MALAYSIA (Peninsular Malaysia, Malacca), *Wallich s.n.*, holotype: K [000637629*].
Voucher: Vanikoro, 420–780 m, 18 Jun 2016, *Chen et al. SITW11013*, BSIP!, TNM!

LEPISORUS (J.Sm.) Ching, *Bull. Fan Mem. Inst. Biol.* 4: 47, 56–58 (1933)
Lepisorus accedens (Blume) Hosok., *Trans. Nat. Hist. Soc. Formosa* 31: 477 (1941). E, O
Polypodium accedens Blume, *Enum. Pl. Javae* 2: 121 (1828); *Pleopeltis accedens* (Blume) T.Moore, *Index Fil.* 77 (1857); *Phymatopsis accedens* (Blume) J.Sm., *Hist. Fil.* 104 (1875); *Microsorum accedens* (Blume) Copel., *Univ. Calif. Publ. Bot.* 16: 111 (1929); *Weatherbya accedens* (Blume) Copel., *Ann. Cryptog. Phytopathol.* 5: 191, t. 6 [*Gen. Fil.*] (1947); *Lemmaphyllum accedens* (Blume) Donk, *Reinwardtia* 2: 409 (1954);

Lepidogrammitis accedens (Blume) Saiki, *J. Phytogeogr. Taxon.* 35(2): 80 (1987)
Type: INDONESIA (Java), *Blume 36*, lectotype: L [0052396*], designated by Field (2020); isolectotypes: BM [001039670*], L [0052395*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11186*, BSIP!, TNM!
Note: This species was placed under *Lemmaphyllum* in Chen et al. (2017a), but here we follow Wei et al. (2017), who suggested its placement under *Lepisorus* based on molecular phylogenetic evidence.

Lepisorus mucronatus (Fée) Li Wang, *Bot. J. Linn. Soc.* 162(1): 35 (2010). E, S
Hymenolepis mucronata Fée, *Mém. Foug.* 5: 81 [*Gen. Filic.*] (1852); *Macroplethus mucronatus* (Fée) Tagawa, *Acta Phytotax. Geobot.* 11: 234 (1942); *Belvisia mucronata* (Fée) Copel., *Ann. Cryptog. Phytopathol.* 5: 192 [*Gen. Fil.*] (1947)
Type: PHILIPPINES (Luzon), *Cuming 92*, lectotype: P [00625274*], designated by Christensen (1929); isolectotypes: BM [001039852*], G [00348174] [00348175] [00348176], RB [00691735*], UC [414453*], US [00134711*], W [0052482*] [1889-0220940*].
Voucher: Vanikoro, 120–600 m, 17 Jun 2016, *Chen et al. SITW10595*, BSIP!, TNM!

LEPTOCHILUS Kaulf., *Enum. Filic.* 147 (1824)
Leptochilus macrophyllus (Blume) Noot., *Blumea* 42: 289 (1997). E, L
Grammitis macrophylla Blume, *Enum. Pl. Javae* 2: 119 (1828); *Selliguea macrophylla* (Blume) Blume, *Fl. Javae. Filic.* 127, t. 53 (1830); *Polypodium macrophyllum* (Blume) Reinw., *Fil. Hort. Bot. Lips.* 37, t.25, f.22-23 (1856); *Colysis macrophylla* (Blume) C.Presl, *Epimel. Bot.* 147 (1851 [‘1849’]); *Gymnogramma macrophylla* (Blume) Hook., *Sp. Fil.* 5: 159 (1864); *Pleopeltis macrophylla* (Blume) Alderw., *Bull. Dépt. Agric. Indes Néerl.* 27: 12 (1909)
Type: INDONESIA (Java), *Blume s.n.*, holotype: L [0051796*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, Chen et al. *SITW10483*, BSIP!, TAIF [519949!], TNM!
Note: Zhang et al. (2019) believed that the species circumscription of Nooteboom (1997) was too broad and that plants from the Solomon Islands might represent an undescribed species. Further study is needed.

LOXOGRAMME (Blume) C.Presl, *Tent. Pterid.* 214 (1836)
Loxogramme parksii Copel., *Bull. Bernice P. Bishop Mus.* 59: 18 (1929). E, E
Type: FIJI, *Parks 20481*, holotype: UC [351294*]; isotypes: BISH [1000362*], BM [001039918*], MICH [1190727*].
Voucher: Kolombangara, 600–700 m, 5 Aug 2013, *Chen et al. SITW03011*, BSIP!, TAIF [445106!], TNM!

Loxogramme scolopendrioides (Gaudich.) C.V.Morton, *Contr. U.S. Natl. Herb.* 38: 242 (1973). E, L
Grammitis scolopendrioides Gaudich., *Voy. Uranie* 310 (1827)
Type: INDONESIA (Indonesian New Guinea), *Gaudichaud s.n.*, holotype: P [00625632*]; isotype: FI [004225*].
Voucher: New Georgia, 200–250 m, 21 Jun 2013, *Chen et al. SITW02799*, BSIP!, TAIF [445893!], TNM!

MICROSORUM Link, *Hort. Berol.* 2: 110 (1833)
Microsorum biseriatum (Bosman) Noot., *Blumea* 42: 315 (1997). T, B
Phymatosorus biseriatus Bosman, *Leiden Bot. Ser.* 14: 127 (1991)
Type: PAPUA NEW GUINEA (New Ireland), *Croft 1870*, holotype: L [0053142*] [0053143*]; isotypes: A, CANB [CBG9403958*], CHR, K [000603502*] [000603503*], LAE, NSW.
Voucher: Santa Isabel, 600–1000 m, 16 Jul 2014, *Chen et al. SITW05418*, BSIP!, TAIF [471905!] [471906!], TNM!

Microsorum commutatum (Blume) Copel., *Ann. Cryptog. Phytopathol.* 5: 196 [*Gen. Fil.*] (1947). T, N
Polypodium commutatum Blume, *Enum. Pl. Javae* 2: Add. 3 (1828); *Pleopeltis commutata* (Blume) Alderw., *Bull. Dépt. Agric. Indes Néerl.* 27: 9 (1909); *Phymatodes commutata* (Blume) Ching, *Bull. Fan Mem. Inst. Biol.* 10: 239 (1941); *Phymatosorus commutatus* (Blume) Pic.Serm., *Webbia* 28: 459 (1973)
Type: INDONESIA (Java), *Blume 191*, holotype: L [0053640*].
Voucher: Rennell, 20–50 m, 3 Jul 2014, *Chen et al. SITW05343*, BSIP!, TAIF [471921*] [471922*], TNM!

Microsorum congregatifolium (Alderw.) Holttum, *Rev. Fl. Malaya* 2: 178 (1955). E, E
Pleopeltis congregatifolia Alderw., *Malayan Ferns Fern Allies* 396 (1917)
Type: INDONESIA (Sumatra), *Lörzing 5532*, lectotype: BO, designated by Bosman (1991); isolectotypes: L [0051901*], U [0007484*], UC [265893*], US [00345210*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11164*, BSIP!, TAIF [528823!], TNM!
Note: This species was unidentified in Chen et al. (2017a: 498–499). Newly recorded from the Solomon Islands.

Microsorum cromwellii (Rosenst.) Copel., *Ann. Cryptog. Phytopathol.* 5: 197 [*Gen. Fil.*] (1947). E, E
Polypodium cromwellii Rosenst., *Repert. Spec. Nov. Regni Veg.* 10: 340 (1912); *Pleopeltis cromwellii* (Rosenst.) Alderw., *Malayan Ferns Fern Allies* 392 (1917); *Phymatosorus cromwellii* (Rosenst.) Nakaike, *Bull. Natl. Sci. Mus. Tokyo, B* 4(3): 128 (1978)
Type: PAPUA NEW GUINEA, *Bamler K12*, lectotype: P, designated by Nooteboom (1997); isolectotype: NY [00127696*].
Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11177*, BSIP!, TNM!
Note: This species was placed under *M. scolopendria* (Burm.f.) Copel. (as the montane form) in Chen et al. (2017a). Our unpublished genetic data show that it is not closely related to *M. scolopendria* and should be recognised as a separate species. We disagree with Nooteboom (1997) who synonymised *M. cromwellii* under *M. papuanum* (Baker) Parris.

Microsorum glossophyllum (Copel.) Copel., *Ann. Cryptog. Phytopathol.* 5: 196 [*Gen. Fil.*] (1947). E, E
Polypodium glossophyllum Copel., *Philipp. J. Sci., C.* 9: 7 (1914)
Type: PAPUA NEW GUINEA, *King 388*, holotype: MICH [1190853*]; isotypes: BM [001038366*], P [00626785*] [00626786*], SYD.

Voucher: Guadalcanal, 400–800 m, 17 Jul 2016, *Chen et al. SITW11151*, BSIP!, TNM!

Microsorum grossum (Langsd. & Fisch.) S.B.Andrews, *Ferns of Queensland* 280 (1990). T, K

Polypodium grossum Langsd. & Fisch., *Pl. Voy. Russes Monde* 9, t.8 (1810); *Drynaria grossa* Fée, *Mém. Foug.* 5: 270 [*Gen. Filic.*] (1852); *Phymatodes grossa* C.Presl, *Tent. Pterid.* 196 (1836); *Phymatosorus grossus* (Langsd. & Fisch.) Brownlie, *Nova Hedwigia* 55: 385 (1977)

Type: FRENCH POLYNESIA (Marquesas), *Langsdorff & Fischer s.n.*, holotype: LE [0107897*]; isotype: BM [001038377*].

Voucher: Tetepare, 0–200 m, 24 Aug 2013, *Chen et al. SITW03348*, BSIP!, TAIF [448687!], TNM!

Note: Phylogenetic analysis by Chen et al. (2020) shows a close affinity between a specimen (*Chen et al. SITW03348 = Wade 2910*) from the Solomon Islands and specimens of *M. grossum* from Hawaii and Moorea, suggesting the occurrence of *M. grossum* in the Solomon Islands.

Microsorum nigrescens (Blume) Copel., *Occas. Pap. Bernice Pauahi Bishop Mus.* 14: 74 (1938). T, R

Polypodium nigrescens Blume, *Enum. Pl. Javae* 2: 126 (1828); *Phymatodes nigrescens* (Blume) J.Sm., *Ferns Brit. For.* 94 (1866); *Pleopeltis nigrescens* (Blume) Carruth., *Fl. Vit.* 368 (1873); *Phymatosorus nigrescens* (Blume) Pic.Serm., *Webbia* 28: 459 (1973); *Leptochilus nigrescens* (Blume) L.Y.Kuo, *Taiwania* 64: 379 (2019)

Type: INDONESIA (Java), *Reinwardt 68*, lectotype: L [3580788*], designated by Hovenkamp (2019).

Note: This species has usually been treated as a synonym of *M. membranifolium* (R.Br.) Ching, as in Chen et al. (2017a). However, after comparing specimens of both names from their type localities, we think they are two different species, and the Solomon Islands plants are *M. nigrescens*. Phylogenetic analysis by Chen et al. (2020) shows that as currently circumscribed *Microsorum* is paraphyletic and a specimen of *M. nigrescens* from the Solomon Islands is resolved in the sister clade of *Leptochilus*. The generic placement of this species is likely to change in the future, but here we adopted the conventional placement under *Microsorum*.

Microsorum papuanum (Baker) Parris, *Kew Bull.* 41(1): 70 (1986). E, B

Polypodium papuanum Baker, *Malesia* 3: 48 (1886); *Pleopeltis papuana* (Baker) Alderw., *Bull. Dépt. Agric. Indes Néerl.* 27: 5 (1909); *Phymatosorus papuanus* (Baker) S.Matsumoto, *Ann. Tsukuba Bot. Gard.* 17: 30, 93 (1998)

Type: INDONESIA (Indonesian New Guinea), *Beccari s.n.*, holotype: K [000599170*]; isotype: FI [013642*].

Voucher: Rennell, 20–50 m, 3 Jul 2014, *Chen et al. SITW05316*, BSIP!, TAIF [471776!], TNM!

Microsorum powellii (Baker) Copel., *Ann. Cryptog. Phytopathol.* 5: 196 [*Gen. Fil.*] (1947). E, N

Polypodium powellii Baker, *Syn. Fil.* 364 (1868); *Pleopeltis powellii* (Baker) Carruth., *Fl. Vit.* 367 (1873); *Phymatodes powellii* (Baker) Ching, *Bull. Fan Mem. Inst. Biol.* 10: 239 (1941); *Phymatosorus powellii* (Baker) Pic.Serm., *Webbia* 28: 459 (1973); *Zealandia powellii* (Baker) Testo & A.R.Field, *Syst. Bot.* 44(4): 13 (2019)

Type: SAMOA, *Powell 135*, holotype: K [000804531*] [000804532*].
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04893*, BSIP!, TAIF [463426!], TNM!
Note: Phylogenetic analyses of Testo et al. (2019) and Chen et al. (2020) resolved this species in two different places. The former resolved a specimen from Moorea, Polynesia (*Nitta 654*) in a new genus *Zealandia*, whereas the latter resolved a specimen from the Solomon Islands (*Chen et al. SITW04893 = Chen Wade 3352*) in core *Microsorum*. Apparently, these two specimens represent different species, or it is possible that *M. powellii* is of hybrid origin (Testo et al., 2019). A specimen from the type locality, Samoa, should be included in future analyses to help determine the placement of this species.

Microsorum punctatum (L.) Copel., *Univ. Calif. Publ. Bot.* 16: 111 (1929). E, T
Acrostichum punctatum L., *Sp. Pl.,* ed. 2, 2: 1524 (1763); *Polypodium punctatum* (L.) Sw., *J. Bot. (Schrader)* 1800(2): 21 (1801), *non* Thunb., *Syst. Veg.,* ed. 14: 939 (1784).; *Pleopeltis punctata* (L.) Bedd., *Suppl. Ferns S. Ind.* 22 (1876)
Type: CHINA (Guangdong), *Wang 32560*, neotype: PE [00943781*], designated by Mazumdar & Shalimov (2016).
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10474*, BSIP!, TAIF [519961!], TNM!

Microsorum scolopendria (Burm.f.) Copel., *Univ. Calif. Publ. Bot.* 16: 112 (1929). E, T
Polypodium scolopendria Burm.f., *Fl. Indica* 232 (1769); *Phymatodes scolopendria* (Burm.f.) Ching, *Contr. Inst. Bot. Nat. Acad. Peiping* 2: 63 (1933); *Phymatosorus scolopendria* (Burm.f.) Pic.Serm., *Webbia* 28: 460 (1973)
Type: INDONESIA (Java), *Pryon s.n.*, lectotype: G-PREL [00360042*], designated by Hovenkamp (2019).
Voucher: Rennell, 20–50 m, 3 Jul 2014, *Chen et al. SITW05315*, BSIP!, TAIF [471777!], TNM!

OREOGRAMMITIS Copel., *Philipp. J. Sci., C.* 12: 64 (1917)
The revised generic circumscription of *Oreogrammitis* of Parris & Sundue (2020) is adopted here. As a result, the species under *Radiogrammitis* and *Themelium* in Chen et al. (2017a) are now placed in *Oreogrammitis*.

Oreogrammitis adspersa (Blume) Parris, *Gard. Bull. Singapore* 58(2): 255 (2007). E, R
Polypodium adspersum Blume, *Enum. Pl. Javae* 2: 113 (1828), *non* Schrad., *Gott. gel. Anz.* 915 (1818); *Grammitis adspersa* Blume, *Fl. Javae Fil.* 115, t.48, f.2 (1830)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L [0051636!], designated by Parris (1983); isolectotype: L [0051637!].
Voucher: Guadalcanal, c. 600 m, 23 Jul 2016, *Chen et al. SITW11683*, AK!, BSIP!, TAIF! TNM!
Note: The illustrations of *O. curtipila* in Chen et al. (2017a) depict this species.

Oreogrammitis brassii (Copel.) Parris, *Gard. Bull. Singapore* 58(2): 257 (2007). E, A
Grammitis brassii Copel., *Philipp. J. Sci.* 60: 112, t.21 (1936)
Type: SOLOMON ISLANDS (Makira), *Brass 2926*, lectotype: GH [00021248!], designated by Parris (2007); isolectotypes: BRI [AQ0147393*], GH [00021249!], MICH

[1287183*].
Voucher: Makira, 487 m [1600 ft], 9 Aug 1965, *Braithwaite RSS 4311*, BSIP!, K!
Note: Two images of *O. merrillii* (*Chen et al. SITW10511*) were misattributed to this species in Chen et al. (2017a). The species is endemic and known only from two collections, both from Makira.

Oreogrammitis curtipila (Parris) Parris, *Gard. Bull. Singapore* 58(2): 258 (2007). E, B
Grammitis curtipila Parris, *Blumea* 29(1): 112 (1983)
Type: PAPUA NEW GUINEA, *Brass 25776*, holotype: K [000009159!]; isotypes: A, CANB [56880!], K, L [0051646!], LAE, PNH, US [00048650!].
Voucher: Guadalcanal, 2130 m, 29 Oct 1965, *Braithwaite RSS 4688*, K!
Note: All material of *Chen et al. SITW11001* illustrated in Chen et al. (2017a) is *O. adspersa*.

Oreogrammitis dissimulans Parris, *sp. nov.* E, A
Type: see section describing new species.
Note: Endemic. There is one sterile frond of this species that has been wrongly placed under *Chen et al. SITW11001*, which is *O. adspersa*.

Oreogrammitis graminella (C.Chr.) Parris & Sundue, *Phytotaxa* 436(1): 48 (2020). E, D
Polypodium simplex Baker, *J. Bot.* 14: 12 (1876), *non* Burm.f., *Fl. Indica* 235 (1768); *Polypodium graminellum* C.Chr., *Index Filic.* 530 (1906); *Grammitis graminella* (C.Chr.) Sledge, *Brit. Fern Gaz.* 9: 340 (1967); *Radiogrammitis graminella* (C.Chr.) Parris, *Gard. Bull. Singapore* 58(2): 242 (2007)
Type: SAMOA, *Whitmee 123*, lectotype: K [000604749!], designated here by Parris; isolectotypes: BM [001039753*], CGE!, E [00194132!], GH [00021898*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11684*, BSIP!, TNM!

Oreogrammitis jagoriana (Mett. ex Kuhn) Parris & Sundue, *Phytotaxa* 436(1): 49 (2020). E, L
Polypodium jagorianum Mett. ex Kuhn, *Linnaea* 36(1): 128 (1869); *Grammitis jagoriana* (Mett. ex Kuhn) Tagawa, *Acta Phytotax. Geobot.* 10(4): 284 (1941); *Radiogrammitis jagoriana* (Mett. ex Kuhn) Parris, *Gard. Bull. Singapore* 58(2): 242 (2007)
Type: PHILIPPINES, *Jagor 835*, lectotype: B [20 0090523!], designated by Parris (2007); isolectotypes: BM, K [000549783*].
Voucher: Guadalcanal, 2133 m [7000 ft], 29 Oct 1965, *Braithwaite RSS 4687*, K!

Oreogrammitis knutsfordiana (Baker) Parris, *Gard. Bull. Singapore* 58(2): 261 (2007). E, N
Polypodium knutsfordianum Baker, *J. Bot.* 107 (1890); *Grammitis knutsfordiana* (Baker) Copel., *Univ. Calif. Publ. Bot.* 18: 224 (1942)
Type: PAPUA NEW GUINEA, *MacGregor 29*, holotype: K [000570976!].
Voucher: Guadalcanal, 2133 m [7000 ft], 27 Oct 1965, *Braithwaite RSS 4665*, BSIP!, K!, L [3547685*], LAE!

Oreogrammitis merrillii (Copel.) Parris, *Gard. Bull. Singapore* 58(2): 263 (2007). E, E
Polypodium merrillii Copel., *Fragm. Fl. Philipp.* 188 (1905); *Grammitis merrillii*

(Copel.) Copel., *Philipp. J. Sci.* 80: 224 (1952)
Type: PHILIPPINES, *Merrill 754*, lectotype: US [00139170!], designated by Parris (1983); isolectotype: K [000009162!].
Voucher: San Jorge, 20–450 m, 6 Jun 2016, *Chen et al. SITW10511*, AK [368112!], BSIP!, TAIF [498607!] [519879!], TNM!
Note: Two images of this species (*Chen et al. SITW10511*) were misattributed to *O. brassii* in Chen et al. (2017a). Newly recorded from the Solomon Islands.

Oreogrammitis oblanceolata (Baker) Parris, *Gard. Bull. Singapore* 58(2): 264 (2007). E, E
Polypodium oblanceolatum Baker, *Ann. Bot. (Oxford)* 8: 128 (1894); *Grammitis oblanceolata* (Baker) Copel., *Philipp. J. Sci*. 80: 166, f.34 (1952)
Type: PAPUA NEW GUINEA, *MacGregor 96*, holotype: K [000558468!].
Voucher: Kolombangara, 1350 m, 9 Aug 1991, *Glenny 3184*, BSIP!, WELT [P017088!].

Oreogrammitis parva (Brause) Parris & Sundue, *Phytotaxa* 436(1): 50 (2020). E, E
Polypodium parvum Brause, *Bot. Jahrb. Syst*. 49(1): 36 f. 2C (1912); *Grammitis parva* (Brause) Copel., *Ann. Cryptog. Phytopathol*. 5: 211 [*Gen. Fil.*] (1947); *Radiogrammitis parva* (Brause) Parris, *Gard. Bull. Singapore* 58(2): 244 (2007)
Type: PAPUA NEW GUINEA, *Schlechter 17156*, lectotype: B [20 0146528!], designated by Parris (1983); isolectotypes: BISH [105767!] [105768!], BM [001039778!] [001039779!], K [000558620!], L!, MICH [1190881!], P, UC [227237!].
Voucher: Guadalcanal, 1100–1300 m, 16 Sep 2015, *Hsu et al. SITW09866*, BSIP!, TAIF [516353!], TNM!
Note: Newly recorded from the Solomon Islands.

Oreogrammitis peregrina Parris, *sp. nov.* E, A
Type: see section describing new species.
Note: Endemic and known only from the type collection.

Oreogrammitis pleurogrammoides (Rosenst.) Parris, *Gard. Bull. Singapore* 58(2): 266 (2007). E, N
Polypodium pleurogrammoides Rosenst., *Repert. Spec. Nov. Regni Veg*. 5: 42 (1908); *Grammitis pleurogrammoides* (Rosenst.) Copel., *Occas. Pap. Bernice Pauahi Bishop Mus*. 15: 86 (1939)
Type: PAPUA NEW GUINEA, *Werner 22*, lectotype: UC [391434!], designated by Parris (1983); isolectotype: S-P [6718!].
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07590*, BSIP!, TAIF [486593!], TNM!

Oreogrammitis reinwardtii (Blume) Parris, *Gard. Bull. Singapore* 58(2): 266 (2007). E, Q
Grammitis reinwardtii Blume, *Enum. Pl. Javae* 2: Add. 2 (1828); *Polypodium reinwardtii* (Blume) C.Presl, *Tent. Pterid*. 180 (1836)
Type: INDONESIA (Sulawesi), *Reinwardt 104*, lectotype: L, designated by Parris (1983).
Voucher: Vanikoro, 420–780 m, 18 Jun 2016, *Chen et al. SITW11019*, BSIP!, TAIF [498879!], TNM!

Oreogrammitis rupicola Parris, *sp. nov.* R, A
Type: see section describing new species.
Note: This species was illustrated in Chen et al. (2017a) under the name *Radiogrammitis* sp. It is endemic and known only from the type collection.

Oreogrammitis setigera (Blume) T.C.Hsu, *Taiwania* 64(4): 379 (2019). E, P
Polypodium setigerum Blume, *Enum. Pl. Javae* 2: 123 (1828); *Grammitis setigera* (Blume) Ching, *Bull. Fan Mem. Inst. Biol.* 10: 241 (1941), *non* J.Sm., *Hist. Fil.* 181 (1875); *Radiogrammitis setigera* (Blume) Parris, *Gard. Bull. Singapore* 58(2): 244 (2007)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L, designated by Parris (1983); isolectotypes: K, L.
Voucher: Guadalcanal, 1300–1700 m, 15 Sep 2015, *Hsu et al. SITW09872*, BSIP!, TAIF [516251!], TNM!

Oreogrammitis setulifera (Alderw.) Parris, *Gard. Bull. Singapore* 58(2): 268 (2007). E, E
Polypodium setuliferum Alderw., *Bull. Jard. Bot. Buitenzorg*, ser. 2, 16: 32 (1914); *Xiphopteris setulifera* (Alderw.) Parris, *Kew Bull.* 41(1): 69 (1986); *Radiogrammitis setulifera* (Alderw.) Parris, *Fern Gaz.* 20(4): 163 (2016); *Grammitis setulifera* (Alderw.) Christenh., *Global Fl.* 4: 48 (2018)
Type: INDONESIA (Sumatra), *Matthew 651*, lectotype: K [000501091!, as *Matthew 657*], designated here by Parris, isolectotype: E [00194034!, as *Matthew s.n.*].
Voucher: Malaita, 900 m, 2 Aug 2015, *Chang et al. SITW08471*, BSIP!, TAIF [495062!], TNM!
Note: Newly recorded from the Solomon Islands.

Oreogrammitis subevenosa (Baker) Parris, *Fern Gaz.* 19(6): 207 (2013). E, L
Polypodium subevenosum Baker, *Syn. Fil.* 320 (1868); *Grammitis subevenosa* (Baker) C.Chr. & Tardieu, *Notul. Syst.* 8: 179 (1939)
Type: MALAYSIA (Peninsular Malaysia, Penang), *Mactier s.n.*, holotype: K [001044343!]; isotypes: E [00195211!] [00195212!].
Voucher: Nggatokae, 50–850 m, 9 Oct 2013, *Chen et al. SITW04879*, BSIP!, TAIF [463411!], TNM!

Oreogrammitis subreticulata (Copel.) Parris, *Gard. Bull. Singapore* 58(2): 269 (2007). E, B
Polypodium subreticulatum Copel., *Philipp. J. Sci., C.* 9: 6 (1914); *Grammitis subreticulata* (Copel.) Copel., *Philipp. J. Sci.* 80: 185, f.54 (1952)
Type: PAPUA NEW GUINEA, *Shaw* in *King 395*, lectotype: MICH [1190901!], designated by Parris (1983); isolectotypes: BM [001039764!], NSW.
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11688*, BSIP!, TNM!
Note: Newly recorded from the Solomon Islands.

Oreogrammitis tenuisecta (Blume) T.C.Hsu, *Taiwania* 64(4): 379 (2019). E, R
Polypodium tenuisectum Blume, *Enum. Pl. Javae* 2: 134 (1828); *Ctenopteris tenuisecta* (Blume) J.Sm., *Hist. Fil.* 185 (1875); *Grammitis tenuisecta* (Blume) Ching, *Bull. Fan Mem. Inst. Biol.* 10: 241 (1941); *Themelium tenuisectum* (Blume) Parris, *Kew Bull.* 52(3): 740 (1997)

Type: INDONESIA (Java), *Blume s.n.*, holotype: L!
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07558*, BSIP!, TNM!

Oreogrammitis torricelliana (Brause) Parris, *Gard. Bull. Singapore* 58(2): 270 (2007). E, E
Polypodium torricellianum Brause, *Bot. Jahrb. Syst.* 49(1): 45, f. 3A (1912); *Grammitis torricelliana* (Brause) Parris, *Fern Gaz.* 12(3): 180 (1981)
Type: PAPUA NEW GUINEA, *Schlechter 14347*, lectotype: B [20 0146513!], designated by Parris (1983).
Voucher: Santa Isabel, 600–1300 m, 16 Jul 2014, *Chen et al. SITW05679*, BSIP!, TAIF [472900!], TNM!

Oreogrammitis yoderi (Copel.) Parris & Sundue, *Phytotaxa* 436(1): 50 (2020). E, E
Polypodium yoderi Copel., *Philipp. J. Sci.* 1(Suppl. 2): 161 (1906); *Ctenopteris yoderi* (Copel.) Copel., *Ann. Cryptog. Phytopathol.* 5: 219 [*Gen. Fil.*] (1947); *Themelium yoderi* (Copel.) Parris, *Kew Bull.* 52(3): 739 (1997); *Grammitis yoderi* (Copel.) Christenh., *Global Fl.* 4: 50 (2018)
Type: PHILIPPINES, *Yoder s.n.*, lectotype: MICH [1259777!], designated by Parris (1997).
Voucher: Guadalcanal, 2133 m [7000 ft], 27 Oct 1965, *Braithwaite RSS 4661*. BSIP!, K!

PROSAPTIA C.Presl, *Tent. Pterid.* 165 (1836)
Prosaptia contigua (G.Forst.) C.Presl, *Tent. Pterid.* 166 (1836). E, S
Trichomanes contiguum G.Forst., *Fl. Ins. Austr.* 84 (1786); *Humata contigua* (G.Forst.) Desv., *Mém. Soc. Linn. Paris* 6(3): 323 (1827); *Polypodium contiguum* (Forst.) J.Sm., *J. Bot.* 3: 394 (1841); *Davallia contigua* (G.Forst.) Spreng., *J. Bot.* 1799(2): 271 (1799); *Ctenopteris contigua* (G.Forst.) Holttum, *Rev. Fl. Malaya* 2: 230, f.130 (1955); *Grammitis contigua* (C.Presl) Christenh., *Global Fl.* 4: 42 (2018)
Type: FRENCH POLYNESIA (Society Islands), *Forster s.n.*, lectotype: BM [001048391!], designated by Parris (2002).
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04933*, BSIP!, TAIF [463827!], TNM!

Prosaptia rosenstockii Copel., *Univ. Calif. Publ. Bot.* 12: 404 (1931). E, B
Grammitis rosenstockii (Copel.) Christenh., *Global Fl.* 4: 48 (2018)
Type: PAPUA NEW GUINEA, *Bamler 23*, holotype: UC [391612!]; isotypes: NY [00127842*], S-P [16672*].
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10450*, BSIP!, TAIF [519942!], TNM!
Note: *Prosaptia kajewskii* Parris, *ined.*, based on *Kajewski 627* from Vanikoro belongs here.

Prosaptia shawii (Copel.) Parris, *Kew Bull.* 50(1): 166 (1995). E, B
Polypodium shawii Copel., *Philipp. J. Sci., C.* 9: 6 (1914); *Ctenopteris shawii* (Copel.) Copel., *Philipp. J. Sci.* 81: 112, t.7 (1953); *Grammitis shawii* (Copel.) Christenh., *Global Fl.* 4: 48 (2018)
Type: PAPUA NEW GUINEA, *Shaw* in *King 424*, lectotype: MICH [1229103!],

designated by Parris (1995).
Voucher: Guadalcanal, 1300–1700 m, 23 Jul 2016, *Chen et al. SITW11680*, BSIP!, TAIF [498902!] [498903!], TNM!
Note: This species was illustrated as *Prosaptia* sp. in Chen et al. (2017a: 511). *Prosaptia solomonensis* Parris, *ined.*, based on *Braithwaite RSS 4787* from Guadalcanal belongs here.

PYRROSIA Mirb., *Hist. Nat. Vég.* 3: 471 (1803)
Pyrrosia fallax (Alderw.) M.G.Price, *Kalikasan* 3: 177 (1974). E, E
Drymoglossum fallax Alderw., *Philipp. J. Sci., C.* 11: 111, t.6 (1916)
Type: INDONESIA (Maluku, Ambon), *Robinson 9152*, holotype: BO.
Voucher: San Jorge, 20–150 m, 3 Jun 2016, *Chen et al. SITW10494*, BSIP!, TAIF [519927!], TNM!

Pyrrosia lanceolata (L.) Farw., *Amer. Midl. Naturalist* 12: 245 (1931). E, T
Acrostichum lanceolatum L., *Sp. Pl.* 2: 1067 (1753); *Candollea lanceolata* (L.) Mirb. ex Desv., *Mem. Soc. Linn. Paris* 6: 224 (1827); *Dendroglossa lanceolata* (L.) C.Presl, *Epimel. Bot.* 149 (1851 ['1849']); *Gymnopteris lanceolata* (L.) T.Moore, *Index Fil.* 3: 10 (1857); *Niphobolus lanceolatus* (L.) Trimen; *J. Linn. Soc., Bot.* 24: 152 (1886), *non* Keyserl., *Polyp. Herb. Bunge* 39 (1873); *Cyclophorus lanceolatus* (L.) Alston, *J. Bot.* 102 (1931)
Type: SRI LANKA, *Herb. Hermann 1: 3, 380*, lectotype: BM [000621235*], designated by Tardieu-Blot (1964).
Voucher: Guadalcanal, 50–150 m, 11 Jul 2016, *Chen et al. SITW11099*, BSIP!, TNM!

Pyrrosia longifolia (Burm.f.) C.V.Morton, *J. Wash. Acad. Sci.* 36: 168 (1946). E, S
Acrostichum longifolium Burm.f., *Fl. Indica* 228 (1768); *Candollea longifolia* (Burm.f.) Mirb., *Hist. Nat. Vég.* 5: 88 (1803); *Cyclophorus longifolius* (Burm.f.) Desv., *Mag. Neuesten Entdeck. Gesammten Naturk. Ges. Naturf. Freunde Berlin* 5: 301 (1811); *Niphobolus longifolius* (Burm.f.) Spreng., *Syst. Veg.*, ed. 16, 4(1): 45 (1827)
Type: INDONESIA (Java), *Pryon s.n.*, lectotype: G-PREL [00801094*], designated by Hovenkamp (1986).
Voucher: Vanikoro, 20–250 m, 20 Jun 2016, *Chen et al. SITW11026*, BSIP!, TNM!

SCLEROGLOSSUM Alderw., *Bull. Jard. Bot. Buitenzorg*, ser. 2, 7: 37, t.5 (1912)
Scleroglossum pusillum (Blume) Alderw., *Bull. Jard. Bot. Buitenzorg*, ser. 2, 7: 39 (1912). E, L
Vittaria pusilla Blume, *Enum. Pl. Javae* 2: 199 (1828); *Taenitis pusilla* (Blume) Mett., *Ann. Mus. Bot. Lugduno-Batavi* 4: 172 (1869); *Pleurogramme pusilla* (Blume) Christ, *Philipp. J. Sci., C.* 2: 175 (1907); *Cochlidium pusillum* (Blume) Copel., *Univ. Calif. Publ. Bot.* 16: 108 (1929)
Type: INDONESIA (Java), *Blume s.n.*, lectotype: L!, designated here by Parris; isolectotypes: L!, P [01344358*].
Voucher: Guadalcanal, 2133 m [7000 ft], 27 Oct 1965, *Braithwaite RSS 4668*, BSIP!, L [3606362*].
Note: The type sheet, L908.322...799, contains 19 plants; we selected the second plant on the left near the top of the sheet, below a very small plant, as the lectotype because it is the largest and most complete plant. Except for one plant of *S. pyxidatum* Alderw.,

lower right, second up from the base of the sheet, the other 17 plants are isolectotypes.
Scleroglossum sulcatum (Mett. ex Kuhn) Alderw., *Bull. Jard. Bot. Buitenzorg*, ser. 2, 7: 39, t.5 (1912). E, R
Vittaria sulcata (Mett. ex Kuhn) Kuhn, *Linnaea* 36(1): 68 (1869); *Taeniopsis sulcata* (Mett. ex Kuhn) Bedd., *Suppl. Ferns S. Ind.* 25 (1876)
Type: SRI LANKA, *Thwaites 3807*, lectotype: B [20 0097599!], designated by Parris (2002); isolectotypes: B [20 0097600!], BM!, BR [0000006964351*], CGE!, GH [00065924!], K [001040221!] [001040224!], LE, P [00625286!], PDA!, W.
Voucher: Kolombangara, 1609 m, 14 Jul 2015, *Chen et al. SITW07595*, BSIP!, TAIF [486589!], TNM!

SELLIGUEA Bory, *Dict. Class. Hist. Nat.* 6: 587–588 (1814)
Selliguea albidosquamata (Blume) Parris, *Pl. Mt. Kinabalu* 152 (1992). E, E
Polypodium albidosquamatum Blume, *Enum. Pl. Javae* 2: 132 (1828); *Drynaria albidosquamata* (Blume) J.Sm., *J. Bot.* 3: 397 (1841); *Phymatodes albosquamata* (Blume) J.Sm., *Ferns Brit. For.* 94 (1866); *Pleopeltis albidosquamata* (Blume) C.Presl, *Tent. Pterid.* 193 (1836); *Crypsinus albidosquamatus* (Blume) Copel., *Ann. Cryptog. Phytopathol.* 5: 207 [*Gen. Fil.*] (1947); *Phymatopsis albidosquamata* (Blume) Ching, *Acta Phytotax. Sin.* 9: 191 (1964); *Phymatopteris albidosquamata* (Blume) Pic.Serm., *Webbia* 28: 461 (1973)
Type: INDONESIA (Sulawesi), *Reinwardt s.n.*, holotype: L.
Voucher: Kolombangara, 1500–1790 m, 20 Jun 2016, *Chen et al. SITW04895*, BSIP!, TAIF [463443!] [463444!], TNM!

Selliguea enervis (Cav.) Ching, *Bull. Fan Mem. Inst. Biol.* 10: 239 (1941). E, L
Polypodium enerve Cav., *Descr. Pl.* 245 (1802); *Crypsinus enervis* (Cav.) Copel., *Ann. Cryptog. Phytopathol.* 5: 207 [*Gen. Fil.*] (1947); *Crypsinopsis enervis* (Cav.) Pic.Serm., *Webbia* 31(1): 242 (1977)
Type: NORTHERN MARIANA ISLANDS, *Nee s.n.*, holotype: MA [476115*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11664*, BSIP!, TNM!

Selliguea plantaginea Brack., *U.S. Expl. Exped., Filic.* 16: 58 (1854). E, N
Type: FRENCH POLYNESIA (Tahiti), *Wilkes Explor. Exped. 3*, holotype: US [00134691*]; isotype: K [001044149*].
Voucher: Kolombangara, 1500–1790 m, 15 Oct 2013, *Chen et al. SITW04920*, BSIP!, TAIF [463836!], TNM!

TOMOPHYLLUM (E.Fourn.) Parris, *Gard. Bull. Singapore* 58(2): 245 (2007)
Tomophyllum pulchrum Parris, *sp. nov.* E, A
Type: see section describing new species.
Note: Endemic and known only from the type collection.

Tomophyllum subrepandulum (Christ) Parris, *Gard. Bull. Singapore* 58(2): 249 (2007). E, E
Polypodium subrepandulum Christ, *Ann. Jard. Bot. Buitenzorg* 20(1): 119 (1905); *Grammitis subrepandula* (Christ) Christenh., *Global Fl.* 4: 49 (2018)
Type: INDONESIA (Kalimantan), *Hallier 3299*, lectotype: BO [1350662! right hand plant], designated here by Parris; isolectotypes: BO [1350662! two plants on left], CAL

[22922*], K [000472792!], S-P [6808*].
Voucher: Guadalcanal, 600–1300 m, 23 Jul 2016, *Chen et al. SITW11676*, BSIP!, TAIF [498904!], TNM!
Note: *Hallier 3299* (BO) was chosen as the lectotype/isolectotype because it is the only material with the name *Polypodium subrepandulum* in Christ's handwriting on a sheet with the printed information "Herb. H. Christ , Bale". The right-hand specimen was chosen as lectotype because it is the largest, and all fronds fit the size dimensions in the original description.

DESCRIPTION OF NEW TAXA

Archigrammitis solomonensis Parris, *sp. nov*. (Figure 3)
A combination of characters distinguishes *A. solomonensis* from all other members of the genus: stipe setae whitish, pale yellow-brown or pale red-brown, c. 2 mm long, lateral veins pinnately branched, hydathodes present on adaxial surfaces of the laminae.
Type: SOLOMON ISLANDS. Western Province, Kolombangara, Patu Kolo to Ibu Rano Lodge, 300–600 m alt., 17 Oct 2013, *Chen et al. SITW04977* (holotype: TAIF [463880!]; isotypes: BSIP!, TNM!).
Plants epiphytic; **rhizomes** short-creeping, not branched; **stipes** articulated to rhizomes; **rhizome scales** narrowly lanceolate, acuminate at apex which is sometimes terete, pale red-brown, with pale red-brown setae on margins and abaxial surface; **stipes** dull dark brown, with dense ± patent whitish to pale red-brown setae c. 2 mm; **laminae** c. 150 × 18 mm, narrowly lanceolate, apex unknown, ± entire, margin slightly undulate-crenulate, with ± patent pale to medium red-brown setae on abaxial surface of lamina and midrib, margins, and adaxial surface of lamina and midrib; **veins** 3–4-forked, each branch ending in a pale, ± elongate hydathode as seen on adaxial surface of lamina; **sori** ± circular to elliptic,

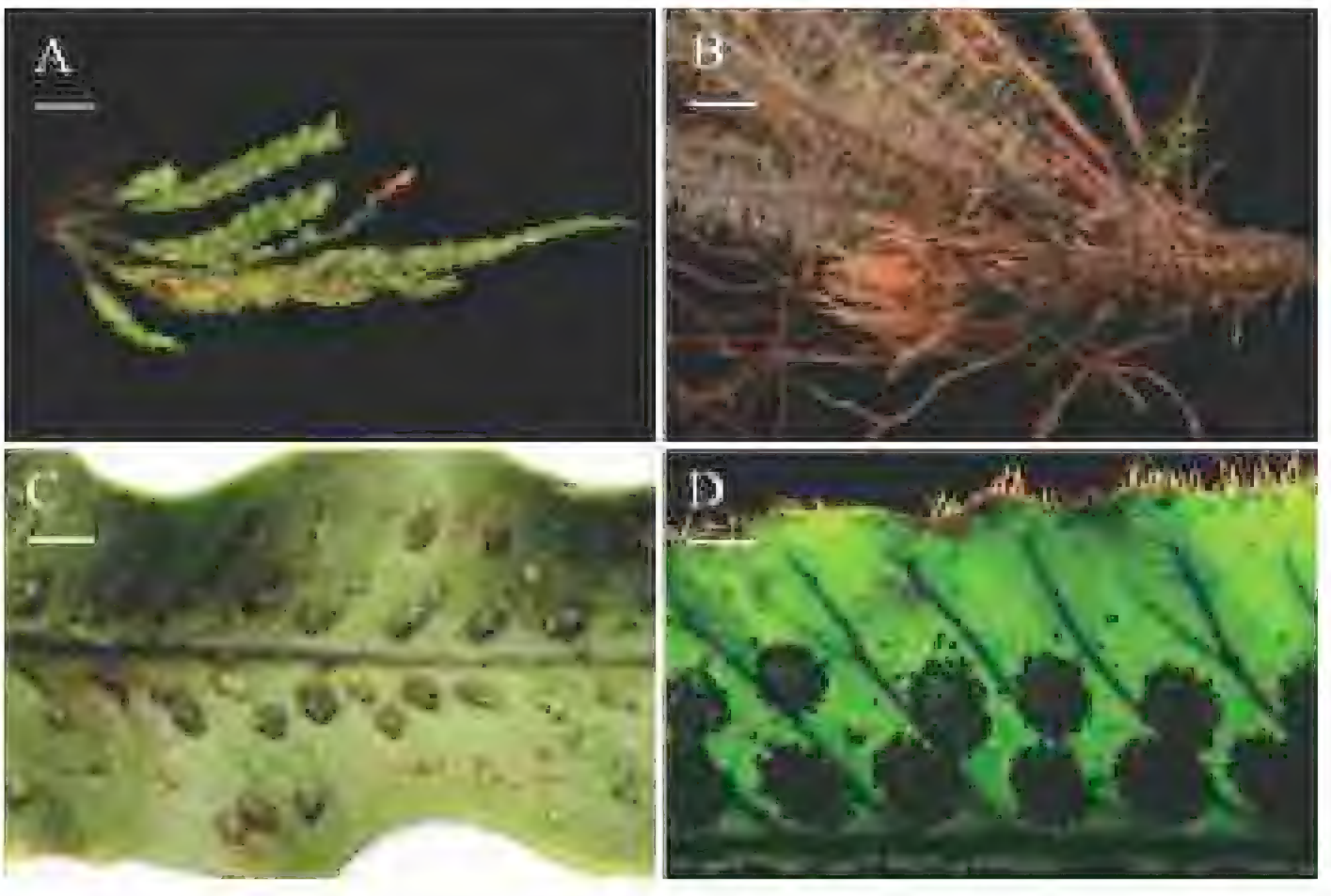

Figure 3. *Archigrammitis solomonensis* Parris (*Chen et al. SITW04977*). A. Plant. B. Rhizome and stipes. C. Abaxial lamina. D. Abaxial lamina with backlight. Scale bars: A = 20 mm, B = 5 mm, C = 3 mm, D = 2 mm. Photographed by T.-C. Hsu.

superficial, in 2–6 rows, 1–3 each on side of midrib; **sporangia** with pale red-brown setae adjacent to annulus.
Etymology – For the Solomon Islands**.**
Habitat – Epiphyte in primary forests, growing with hepatics and mosses, 300–600 m.
Distribution – Endemic to Kolombangara Island in the Solomon Islands.

Calymmodon furcatus Parris, *sp. nov.* (Chen et al., 2017a: 471)
Calymmodon furcatus resembles *C. clavifer* (Hook.) T.Moore in appearance, particularly in having stalked pinnae, but can be distinguished from it by the sterile pinnae being sometimes forked and by the much shorter and sparser hairs.
Type: SOLOMON ISLANDS. Guadalcanal Province, Guadalcanal Island, Mt. Chaunapaho, 9°38'40.8"S 160°6'49"E, c. 600 m alt., 23 Jul 2016, *Chen et al. SITW*11681 (holotype: AK [368089!]; isotypes: BSIP!, TAIF [498901!], TNM!).
Plants epiphytic; **rhizome scales** pale yellow-brown; **stipes** black, glabrous; **laminae** 75–102 × 8–10 mm, narrowly lanceolate, acuminate, pinnate, glabrous or with ± patent whitish setae c. 0.1 mm on abaxial surface of rachis and pale red-brown 1–2-forked hairs on margin; **pinnae** 30–44 pairs, lowest fertile pinnae shorter than uppermost sterile pinnae, longest fertile pinnae 2.6–4.2 × 0.8–1.2 mm, semicircular and obtuse to acuminate when folded, stalk 2.0–2.6 × 0.3–0.5 mm, longest sterile pinnae 5.0–5.7 × 1.0–1.3 mm when simple, 1.0–2.2 mm wide when forked, narrowly oblanceolate when simple, broadly oblanceolate when forked, acuminate or emarginate, lobes 1 per pinna, in distal 1/3 to 1/2 of pinnae, on acroscopic side, longest lobes 1.2–2.2 × 0.5–0.8 mm, narrowly triangular, acuminate; **veins** simple in fertile pinnae, sometimes 1-forked in sterile pinnae, each vein ending in a pale elongate hydathode as seen on adaxial surface of lamina; **sori** broadly elliptic, on 7–24 pairs of pinnae.
Etymology – Latin, *furcatus* = forked, referring to the forked pinnae.
Habitat – Epiphyte in mossy forests, growing with hepatics, at c. 600 m.
Distribution – Endemic to Guadalcanal Island in the Solomon Islands.

Calymmodon solomonensis Parris, *sp. nov.*
Calymmodon solomonensis is distinguished from all other species in the genus by the combination of the following characters: laminae linear, 143–174 × 4–5 mm, lowest fertile pinnae and uppermost sterile pinnae ± equal in length, sterile pinnae broadly to narrowly triangular, and branched hairs 0.1–0.3 mm only on abaxial surface of rachis.
Type: SOLOMON ISLANDS. Guadalcanal Province, Guadalcanal Island, Mt. Popomanaseu (Hai'anja), c. 2290 m alt., 17 Jan 1967, *Dennis BSIP* 7860 (holotype: K [001193728!]; isotype: BSIP!).
Plants epiphytic; **rhizome scales** pale red-brown; **laminae** 143–174 × 4–5 mm, linear, bluntly acute, deeply pinnately divided to wing 0.2–0.3 mm wide along rachis, with pale red-brown 1–2-forked hairs 0.1–0.3 mm on abaxial surface of rachis; **pinnae** 36–46 pairs, entire, lowest fertile pinnae and uppermost sterile pinnae ± equal in length, longest fertile pinnae 2–3 × 0.5 mm, ± semi-circular and bluntly acute when folded, without stalk, longest sterile pinnae 2.5–3.5 × 1.5–1.8 mm, broadly to narrowly triangular, bluntly acute to acute; **veins** simple, each vein ending with a dark elongate hydathode on adaxial surface of lamina; **sori** ± circular, on 14–18 pairs of pinnae.
Etymology – For the Solomon Islands**.**
Habitat – Epiphyte on trunks of small trees in montane mist forests, at c. 2290 m.
Distribution – Endemic to Guadalcanal Island in the Solomon Islands.

Calymmodon subgracilis Parris, *sp. nov.* (Chen et al., 2017a: 468–469)
Calymmodon subgracilis resembles *C. gracilis* (Fée) Copel. in indument, particularly in having scattered to frequent setae on the pinna veins adaxially in some or all fertile pinnae; in *C. subgracilis* the setae are 0.1–0.3 mm, and in *C. gracilis* they are 0.5–1.2 mm.
Type: SOLOMON ISLANDS. Kolombangara, summit, 5400 ft [1630 m], 2 Sep 1965, *Braithwaite RSS 4419* (holotype: K [001044306 a!]; isotypes: BSIP!, K [001044306 b!]).
Plants epiphytic; **rhizome scales** pale to medium red-brown or pale yellow-brown; **laminae** 29–120+ × 5–8 mm, narrowly lanceolate to narrowly oblanceolate, linear-lanceolate or linear-elliptic, obtuse to acute, deeply pinnately divided to wing 0.1–0.4 mm wide along rachis, with pale red-brown to pale yellow-brown setae 0.1–0.6 mm and pale red-brown to pale yellow-brown 1–3-forked hairs 0.1–0.3 mm on margins and both surfaces of lamina and rachis; **pinnae** 10–41+ pairs, entire, lowest fertile pinnae and uppermost sterile pinnae ± equal in length or lowest fertile pinnae shorter than uppermost sterile pinnae, longest fertile pinnae 2.0–4.1 × 0.8–1.6 mm, narrowly triangular, lanceolate, broadly elliptic or semicircular and obtuse when folded, without stalk, longest sterile pinnae 2.3–4.7 × 1.2–2.1 mm, narrowly triangular, oblong or broadly oblanceolate and obtuse; **veins** simple, each vein ending with a pale to moderately dark ± circular to elongate hydathode on adaxial surface of lamina; **sori** broadly elliptic to elliptic, on 1–29+ pairs of pinnae.
Etymology – Latin, *sub* = almost, and *-gracilis*, referring to the similarity to *Calymmodon gracilis*.
Habitat – Low epiphyte on tree trunks in mossy forests, growing with mosses, hepatics and *Hymenophyllum,* from 600 to 1630 m.
Distribution – Endemic to Guadalcanal Island and Kolombangara Island in the Solomon Islands.
Paratypes – SOLOMON ISLANDS. Guadalcanal: Mt. Chaunapaho, 9°38'S 160°06'E, c. 600 m 23 Jul 20216, *Chen et al. SITW11685* (AK [368091]!, TNM); Mt. Popomanaseu, Vunuvela Kama, 4400 ft, 4 Nov 1965, *Braithwaite RSS4800* (BSIP!, K!); Mt. Popomanaseu, 15 Sep 2015, *Hsu et al. SITW09874* (TAIF [516266!]); Mt. Popomanaseu, 15 Sep 2015, *Hsu et al. SITW09876* (TAIF [516267!]); Kolombangara: Camp 3 to Mt. Veve, 7°57'S 157°04'E, 1500–1750 m, 15 Oct 2013, *Chen et al. SITW04939* (AK [360647!], TNM); Camp 3 to Mt. Veve, 1609 m, 14 Jul 2015, *Chen et al. SITW07605* = *Chen Wade 4476* (AK [359321]!, TAIF [486629!]); Mt. Veve, Camp 2 to Camp 3, 7°58'S 157°05'E, 1200–1700 m, 29 Jul 2013, *Chen et al. SITW07603* = *Chen Wade 2718* (AK [352463!]); Mt. Veve, Patu Kolo to Camp 2, 7°59'S 157°05'E, 100–1200 m, 16 Oct 2012, *Chen et al. SITW01055* (AK [360636!], TNM); West coast, inland from Iri Iri village, Merusu Cove, 4000–5000 ft, 27 Sep 1963, *Whitmore & Grubb s. n.* (BSIP [2092!], K!, SING!).

Calymmodon subtilis Parris, *sp. nov.* (Chen et al., 2017a: 470)
Calymmodon subtilis is distinguished from all other species in the genus by the combination of the following characters: laminae narrowly lanceolate to linear-lanceolate, 32–140 × 4–7 mm, lowest fertile pinnae shorter than uppermost sterile pinnae, sterile pinnae narrowly oblong, oblong, oblanceolate or narrowly oblanceolate, 1.0–5.5 × 0.9–1.7 mm, setae on abaxial surface of rachis 0.1–0.2(–0.4) mm or absent from frond, 1–3-forked hairs 0.1–0.2 mm on both surfaces of rachis.

Type: SOLOMON ISLANDS. Kolombangara, Poitete, 7°53'18"S 157°07'E, 600 m, 18 Jul 1990, *Glenny* 2250 (holotype: WELT [P016609 p. p.!, top left plant]; isotypes: BSIP [21277!], WELT [P016609 p. p.!, bottom left, and right plants]).

Plants epiphytic; **rhizome scales** pale to medium red-brown or medium brown; **laminae** 32–140 × 4–7 mm, narrowly lanceolate to linear-lanceolate, obtuse to acute, deeply pinnately divided to wing 0.1–0.2 mm wide along rachis, with pale red-brown 1–3-forked hairs 0.1–0.2(–0.4) mm on both surfaces of rachis, and sometimes on margins and both surfaces of lamina and veins, and whitish to pale red-brown setae on margins and both surfaces of rachis; **pinnae** 9–39 pairs, entire, lowest fertile pinnae shorter than uppermost sterile pinnae, longest fertile pinnae 1.8–3.1 × 0.6–1.3 mm ± semicircular to oblanceolate, obtuse, when folded, without stalk, longest sterile pinnae 1.0–5.5 × 0.9–1.7 mm, narrowly oblong, oblong, oblanceolate, or narrowly oblanceolate; **veins** simple, each vein ending with a pale to dark ± circular to elongate hydathode on adaxial surface of lamina; **sori** elliptic, on 2–31 pairs of pinnae.

Etymology – Latin, *subtilis* = delicate, referring to the frond.

Habitat – Epiphyte in primary forests, mossy forests, ridge top forests of *Campnosperma brevipetiolata* and *Palaquium*, growing with hepatics, mosses and *Didymoglossum tahitense*, from 600 to 1609 m.

Distribution – Papua New Guinea (Bougainville) and the Solomon Islands (Guadalcanal, Kolombangara, Makira, Rendova, Santa Isabel).

Paratypes – PAPUA NEW GUINEA. Bougainville: south rim of Lake Loloru crater, c. 20 miles N of Buin, 6°30'S 155°38'E, c. 5000 ft, 26 Aug 1964, *Schodde & Craven 3917* p.p. (CANB!).

SOLOMON ISLANDS. Guadalcanal: Mt. Gallego, 30 Jul 2014, *Hsu et al. SITW05146* (TAIF [464647!]); Mt. Chaunapaho, 9°38'S 160°06'E, c. 600 m, 23 Jul 2016, *Chen et al. SITW11686* (AK [368096!]); Mt. Popomanaseu, 15 Sep 2015, *Hsu et al. SITW09875* (TAIF [516268!]); Kolombangara: Camp 3 to Mt Veve, 7°57'S 157°05'E, 1609 m, 14 Jul 2015, *Chen et al. SITW07604 = Chen Wade 4475* (AK [359320!], TAIF [467204!]); Makira: Materato village, Mt. Gasi, 10°34'S 16149'E, 910 m, 1 Jul 20215, *Chen et al. SITW06928 = Chen Wade 4447* (AK [359315!], TAIF [467336!]); Rendova: Ughele Village, 8°28'S 157°21'E, 700–1000 m, 26 Aug 2016, *Chen et al. SITW03444* (AK [36041!], TNM); Santa Isabel: unknown locality, 8°03'S 159°08'E, 16 Jul 2014, *Chen et al. SITW05673 = Chen Wade 4078* (AK [356446!], TAIF [451768!]).

Ctenopterella pacifica Parris, *sp. nov.* (Chen et al., 2017a: 474)

Ctenopterella pacifica is closely related to *C. blechnoides* (Grev.) Parris, and the two species are superficially quite similar. They differ in stipe length, (10–)21–44(–62) mm in *C. pacifica*, (0–)3–10(–22) mm in *C. blechnoides*; hydathodes are evident in *C. blechnoides*, but are absent or very faint in *C. pacifica*; *C. blechnoides* has a lower elevational range (0–)84–550(–850 m) in the Pacific than *C. pacifica* (120–)247–1183(–1845) m; the sterile pinnae of *C. pacifica* are usually 1 mm wider than the fertile pinnae, but in *C. blechnoides* the fertile and sterile pinnae are similar in width. Sometimes the sori are only in one row per pinna on the acroscopic side of the pinnae in *C. pacifica*, while in *C. blechnoides* they are always in two rows per pinna.

Type: SOLOMON ISLANDS. NW Guadalcanal, just below summit of Mt. Gallego, 3000 ft (910 m), 7 Jul 1965, *Braithwaite RSS 4053* (holotype: K [001044317 p. p.!, left hand plant]; isotypes: BSIP!, K! [001044317 p. p.!, middle and right hand plants and fronds], L!).

Plants epiphytic; **rhizomes** short-creeping, sometimes branched; **rhizome scales** linear-lanceolate, acuminate, apex usually terete, pale to medium red-brown, or medium brown; **stipes** not articulated to rhizome, 10–62 mm, with 1–3-forked hairs 0.1–0.2(–0.4) mm; **laminae** 98–281 × 7–21 mm, narrowly elliptic to linear-elliptic, acute to acuminate, usually pinnate, sometimes deeply pinnately divided to wing 0.1–0.2 mm wide along rachis, with dark setae 0.1(–0.2) mm among sporangia, sometimes not visible when sporangia mature, sometimes also elsewhere on lamina, and 1–5-forked hairs 0.1–0.3 mm on both surfaces of rachis, sometimes only in axils of pinnae, sometimes elsewhere on lamina also; **pinnae** 41–108 pairs, longest fertile pinnae 4–15 × 1–2 mm, longest sterile pinnae similar in length but × 2–3 mm wide, entire, narrowly oblong to narrowly triangular, obtuse to acute; **veins** pinnately branched, branch endings usually without obvious hydathodes on adaxial surface of lamina, rarely with very faint hydathodes; **sori** ± circular to elliptic, superficial or slightly sunken in shallow depressions, on 8–64 pairs of pinnae, usually in 2 rows per pinna, 1 each side of costa, sometimes 1 complete row on acroscopic side only, with or without a few on lower side, 1–8 per row on longest pinnae.

Etymology – For the Pacific Ocean**.**

Habitat – Epiphyte in *Casuarina* forests, primary forests, ridge top primary forests, ridge top *Metrosideros collina* forests and mossy forests, growing with hepatics and mosses; from 500 to 1400 m.

Distribution – Papua New Guinea (New Britain, New Ireland, Bougainville), the Solomon Islands (Guadalcanal, Kolombangara, Makira, Qiloe, Rendova, Vanikoro) and Vanuatu (Espiritu Santo, Aneiteum).

Paratypes – PAPUA NEW GUINEA. West New Britain District: Kandrian Subdistrict, Mt. Klangal, 25 miles NNE of Gasmata, 6°S 150°30'E, 800 m, 16 May 1973, *Croft & Katik NGF41251* (K!); Hoskins Subdistrict, crater rim of North Son (extinct), 4°56'S 151°26'E, 900 m, 2 Jun 1973, *Stevens LAE58485* (BISH [400301!], E [00195072!], L!); East New Britain District: Pomio Subdistrict: Mt. Sule, c. 25 miles NNE of Fulleborn Harbour, 5°50'S 150°50'E, 1500 m, 7 May 1973, *Croft & Katik NGF14927* (BISH [400367]!, E [00195073]!, MO!, SING!); New Ireland: West slopes of Mt. Tumbumpo, Central Lelet Plateau, 160 km SE of Kavieng, 40 km SE of Konos, 1400 m, 25 Oct 1984, *Croft 1902* (CHR [244292!], L!, NSW!); Bougainville: south foothill slopes of Lake Loloru crater, 17 miles north of Buin, 6°30'S 155°37', c. 2500 ft, 29 Jul 1964, *Schodde & Craven 3695* (CANB!).

SOLOMON ISLANDS. Guadalcanal: Mt. Gallego, 9°21'S 159°43'E, 30 Jun 2014, *Chen Wade 4038* (AK [356444!], TAIF [451766!]); Mt. Gallego, north side, 9°30'S 160°19'E, 125 m [sic], Jul 1985, *Canarella122* (VT!); Mt. Makarakomburu, 9°45'S 160°03'E, 900 m, 15 May 1990, *Glenny 2118* (BSIP!); Kolombangara: Camp 3 to Mt. Veve, 14 Jul 2015, *Chen et al., SITW07591* (TAIF [486592!]); Camp 2 to Camp 3, 7°58'S 157°05'E, 1200–1700 m, 29 Jul 2013, *Chen et al. SITW02947 = Chen Wade 2701* (AK [352461!], TAIF [445160!]); Patu Kolo to Camp 2, 7°59'S 157°05'E, 1000–1200 m, 16 Oct 2012, *Chen et al. SITW01052* (AK [360634!], TNM); West coast, inland from Iri Iri village, Merusu Cove, 4300 ft, 27 Sep 1963, *Whitmore & Grub s. n.* (BSIP [2084!], K!, L!, SING!); Makira: ridge c. 2.5 miles SE of Wainoni Mission around headwaters of Huni River, 1600 ft, 9 Aug 1965, *Braithwaite RSS4310* (BSIP!, K!, L!); Materato Village to Mt. Gasi, 10°34'S 161°49'E, 910 m, 1 Jul 2015, *Chen et al. SITW06855* (AK [360652!], TNM); c. 7 miles inland from Wainoni, ridge to E of Pagato River, 2400 ft, 3 Aug 1965, *Braithwaite RSS44280* (BSIP!, K!); Ranongga: Qiloe, 8°04'S 156°34'E, 400–700 m, 16

Aug 2013, *Chen et al. SITW03086* (AK [360638!], TNM); Qiloe, 8°03'S 156°34'E, 400–600 m, 16 Aug 2013, *Chen et al. SITW03323 = Chen Wade 2885* (AK [352460!], TAIF [448666!]). Rendova: Ughele, Rendova Peak, 8°27'S 157°21'E, 960 m, 11 Sep 1991, *Glenny 3237* (BSIP!, WELT!); Ughele, 8°28'S 157°21'E, 700–1000 m, 26 Aug 2013, *Chen et al. SITW03431 = Chen Wade 2993* (AK [352462!], TAIF [448581!]); Vanikoro: Ngarabu camp to end of road & follow ridge, 11°37'S 166°53'E, c. 120 m, 17 Jun 20216, *Chen et al. SITW10590* (AK [368106!], TAIF [498564!] [520514!] [520515!]).
VANUATU. Espiritu Santo: San ma, between Camp 2 and summit, 15°21'S 166°44'E, 1846 m, 3 Nov 2006, *Rouhan et al. 618* (P [00591119*]); Aneiteum: Tafea, Nijeptohoh area, 2 km N of Ancro & 6.3 km N of Umej village, 20°11'S 169°51'E, 234 m, 2 Aug 2017, *Plunkett et al. 4088* (NY, PVNH*); without locality, 1854, *MacGillivray s.n.* (CAL [23784*]); south slopes of Inrero, c. 4 km NE by N of Anelcauhat, 500 m from Krafft's logging camp, 1350 ft, 20 Jul 1971, *Braithwaite RSNH2095* (K!, L!, NSW!); Anelgauhat Bay, near summit of mountain, 1500 ft, 9 Mar 1929, *Kajewski 886* (BISH [105778!], K!, UC!).
Note – The elevation of 125 m recorded for *Canarella 122* is well below that recorded elsewhere in the range of the species and is regarded as an error, probably due to confusion with *Ctenopterella blechnoides* (*Canarella s. n.*, *Canarella 622*, both VT), also collected at 125 m from Guadalcanal, Mt. Gallego, north side on the same day. *Ctenopterella blechnoides* and *C. pacifica* have not been collected at the same elevation elsewhere; where they occur in the same area the former always occurs at lower elevations than the latter. In the phylogenetic analysis of Bauret et al. (2017), *Ctenopterella pacifica* (as *Ctenopterella* sp. 2) is sister to a clade containing *Ctenopterella lasiostipes* (Mett.) Parris and *Ctenopterella* sp. 1.

Oreogrammitis dissimulans Parris, *sp. nov.* (Figure 4)
Oreogrammitis dissimulans resembles *O. reinwardtii* in its indument of setae and 1-forked veins with the acroscopic branch very short and not extending beyond the sori. *Oreogrammitis dissimulans* differs in having a radial rhizome with dark brown clathrate scales and in lacking hydathodes at the vein endings on the adaxial surface of the lamina.
Type: SOLOMON ISLANDS. Santa Cruz Province, Vanikoro Island, Ngarabu camp to end of road & follow ridge, ± 10 m, 11°37'42.6"S 166°53'3.3"E, c. 120 m, 17 Jun 2016, *Chen et al. SITW11002* (holotype: AK [368108 p. p.!]; isotypes: AK [368108 p. p.!], BSIP!, TAIF!, TNM!).
Plants epiphytic; **rhizomes** radial, not branched; **rhizome scales** 0.3–1.0 × 0.1–0.3 mm, hidden by stipe bases, lanceolate to narrowly lanceolate, obtuse to bluntly acute, dark brown, clathrate; **stipes** not articulated to rhizome, 4–7 mm, with dark red-brown setae 1.7–2.0 mm; **laminae** 64–119 × 4–6 mm, linear-elliptic, bluntly acute to acuminate, entire, chartaceous, with medium to dark red-brown setae 0.2–2.1 mm on margins and both surfaces of lamina and midrib; **veins** visible in transmitted light, slightly prominent and concolorous with lamina abaxially, 1-forked, acroscopic branch not extending beyond sorus, much shorter than basiscopic branch, branch endings without obvious hydathodes on adaxial surface of lamina; **sori** 5–29 pairs, in one row on each side of midrib.
Etymology – Latin, *dissimulans* = dissembling, referring to the close superficial similarity to *Oreogrammitis reinwardtii*.
Habitat – Epiphyte in primary forests, growing with hepatics and mosses, at c. 120 m.
Distribution – Endemic to Vanikoro Island in the Santa Cruz group, the Solomon Islands.
Paratype – SOLOMON ISLANDS. Santa Cruz Province: Vanikoro Island, Ngarabu camp

to end of road & follow ridge, ± 10 m, 11°37'42.6"S 166°53'3.3"E, c. 120 m, 17 Jun 2016, *Chen et al. SITW11001* p. p. (AK [368107 p. p.!], sterile).

Oreogrammitis peregrina Parris, *sp. nov.* (Figure 5)
Oreogrammitis peregrina is similar in appearance to *O. neocaledonica*, which has longer denser laminar hairs and lacks hydathodes. The branched rhizomes of *O. peregrina* are unique among species of *Oreogrammitis* with radial rhizomes.
Type: SOLOMON ISLANDS. Guadalcanal: Mt. Popomanaseu, 9°40'36.2"S 160°03'33.6"E, c. 1300 m, 15 Sep 2016, *Hsu et al. SITW09*865 (holotype: AK [368102!]; isotypes: BSIP!, TAIF!, TNM!).
Plants epiphytic; **rhizomes** radial, sometimes branched; **rhizome scales** 1.5–3.0 × 0.6–2.0 mm, ovate to lanceolate, acute, pale red-brown, concolorous; **stipes** not articulated to rhizome, 5–8 mm, with dark red-brown setae 1.2–1.5 mm; **laminae** 128–136 × 5–7 mm, linear-elliptic, acute, entire or slightly crenulate, chartaceous, with dark red-brown setae 0.2–1.2 mm on margins and both surfaces of lamina and midrib; **veins** visible in transmitted light, slightly prominent and concolorous with lamina on both surfaces, 1–(2–)forked, acroscopic branch extending beyond sorus or not, shorter than basiscopic branch, each branch ending in a pale to moderately dark elongate hydathode on adaxial surface of lamina; **sori** c. 37 pairs, in one row on each side of midrib.
Etymology – Latin, *peregrina* = unfamiliar, referring to its distinctness from other species in the genus.
Habitat – Epiphyte in mossy forests, growing with hepatics, at c. 1300 m.
Distribution – Endemic to Guadalcanal Island in the Solomon Islands.

Oreogrammitis rupicola Parris, *sp. nov.* (Chen et al., 2017a: 518)

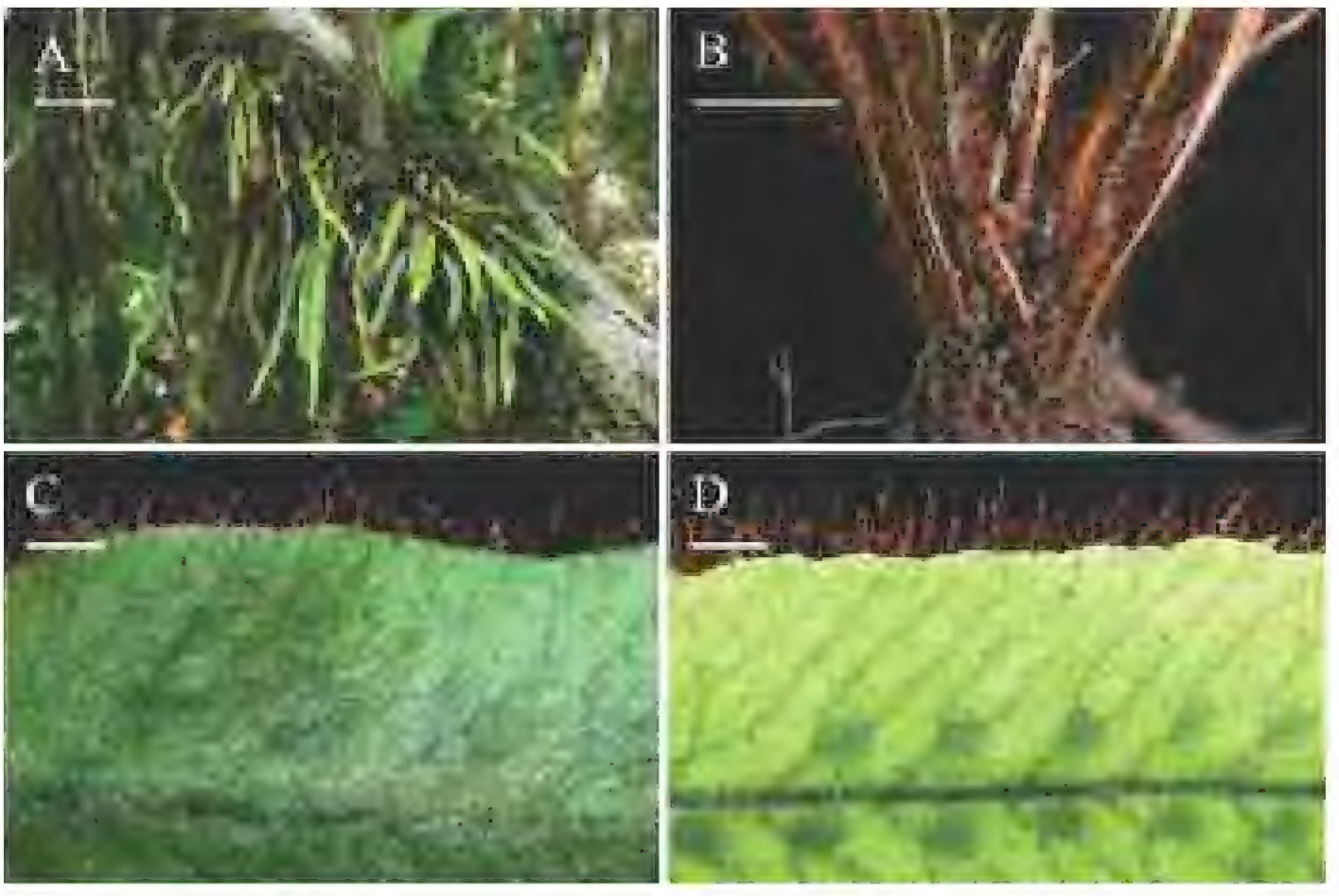

Figure 4. *Oreogrammitis dissimulans* Parris *(Chen et al. SITW11002)*. A. Habit. B. Rhizome and stipes. C. Adaxial lamina. D. Abaxial lamina with backlight. Scale bars: A = 50 mm, B = 5 mm, C = 1 mm, D = 1 mm. Photographed by C.-W. Chen.

Oreogrammitis rupicola is similar to *O. dissimulans* in that they both grow at low elevations on Vanikoro Island in the Solomon Islands and both have small clathrate rhizome scales to 1.0 mm long. The latter differs from the former in being epiphytic, having veins 1-forked and visible in transmitted light rather than simple and invisible in transmitted light, and by its longer setae.

Type: SOLOMON ISLANDS. Santa Cruz Province, Vanikoro Island, stream behind Lavaka village, 11°36'29.3"S 166°54'5.6"E, c. 20 m alt., 21 Jul 2016, *Chen et al. SITW11054* (holotype: AK [368118 p. p.!]; isotypes: AK [368118 p. p.!], BSIP!, TAIF!, TNM!).

Plants lithophytic; **rhizomes** radial, not branched; **rhizome scales** 0.5–1.0 × 0.1–0.4 mm, narrowly ovate to lanceolate, acute, dark brown, clathrate; **stipes** not articulated to rhizome, 4–8 mm, with medium to dark red-brown setae 0.7–1.0 mm; **laminae** 35–58 × 3–5 mm, narrowly elliptic to linear-elliptic, obtuse to acuminate, entire, chartaceous to thinly coriaceous, with medium to dark red-brown setae 0.1–1.3 mm on margin and both surfaces of lamina and midrib; **veins** invisible in transmitted light, not prominent on either surface, simple, not extending beyond sorus, vein endings without obvious hydathodes on adaxial surface of lamina; **sori** 3–15 pairs, in one row on each side of midrib.

Etymology – Latin, *rupicola* = growing on rocks, referring to the habitat, unusual in species of the genus with radial rhizomes.

Habitat – Lithophyte at streamsides in primary forests, growing with hepatics and mosses, at c. 20 m.

Distribution – Endemic to Vanikoro Island, in the Santa Cruz group, the Solomon Islands.

Tomophyllum pulchrum Parris, *sp. nov.* (Figure 6)

Tomophyllum pulchrum can be distinguished from all other species in the genus by the

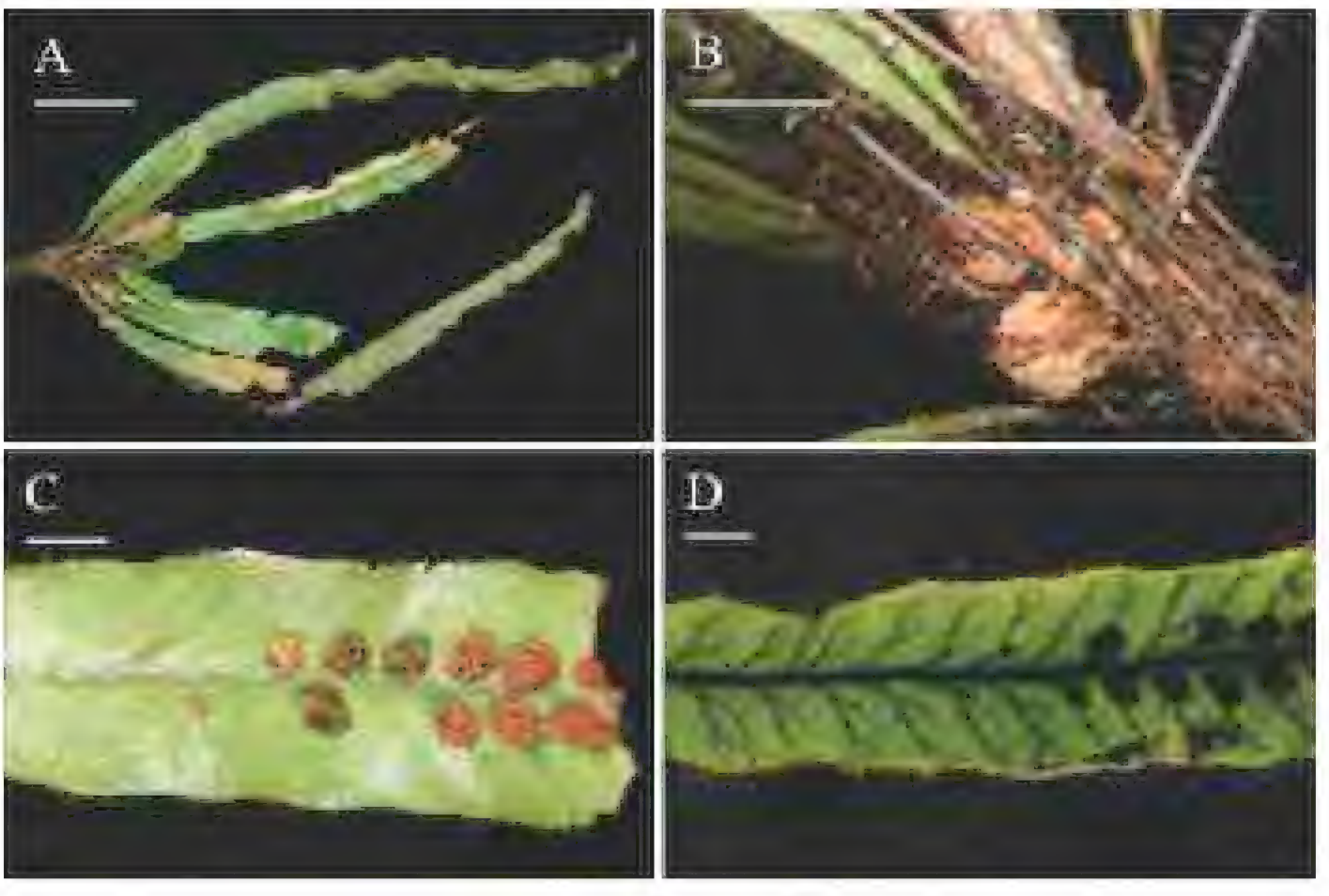

Figure 5. *Oreogrammitis peregrina* Parris *(Hsu et al. SITW09865)*. A. Plant. B. Rhizome and stipes. C. Abaxial lamina. D. Adaxial lamina with backlight. Scale bars: A = 20 mm, B = 5 mm, C = 2 mm, D = 2 mm. Photographed by T.-C. Hsu.

following combination of characters: rhizome scales absent, laminae pinnate, rachis prominent and darker than lamina adaxially, pinnae adnate at their bases acroscopically, pinna margins undulate to crenulate, lobed less than ½ way to costa, setae on abaxial surface of rachis 0.1–0.2 mm, and setae on abaxial surface of lamina not restricted to soral areas.

Type: SOLOMON ISLANDS. Guadalcanal Province, Guadalcanal Island, Haviha River to Valevahalo Camp, ± 10 m, 9°40'7.7"S 160°3'25.2"E, c. 1100 m, 16 Sep 2016, *Hsu et al. SITW9867* (holotype: AK [368104!]; isotypes: BSIP!, TAIF!, TNM!).

Plants epiphytic; **rhizome scales** absent; **stipes** 4–5 × 0.2–0.3 mm, with whitish (to pale red-brown) setae 0.1–0.4 mm; **laminae** 112± × 15 mm, narrowly elliptic, apex unknown, pinnate; **pinnae** 48+ pairs, longest pinnae 6–7 × 2 mm, narrowly oblong to narrowly triangular, obtuse to acute, adnate on acroscopic margin, proximally slightly decurrent basiscopically, margins undulate or crenulate, teeth to 0.5 mm, thinly chartaceous, with whitish (to pale red-brown) setae on margins and both surfaces of lamina, costae, and rachis, 0.1–0.2 mm on abaxial surface of rachis, 0.1–0.4 on adaxial surface of rachis, c. 0.1 mm elsewhere; **rachis**es prominent and darker than lamina on both surfaces; **veins** visible in transmitted light, pinnately branched, each branch ending in a pale to dark elongate hydathode; **sori** on surface of lamina or very slightly sunken in broad shallow depressions, embossed adaxially, on c. 29 pairs of pinnae, 3–4 pairs per pinna, in one row on each side of costae.

Etymology – Latin, *pulchrum* = beautiful, referring to the appearance of the plant.

Habitat – Epiphyte in understory forests, growing with hepatics, at c. 1100 m.

Distribution – Endemic to Guadalcanal Island in the Solomon Islands.

Figure 6. *Tomophyllum pulchrum* Parris *(Hsu et al. SITW09867)*. A. Plant. B. Rhizome and basal fronds. C. Abaxial lamina. D. Abaxial lamina with backlight. Scale bars: A = 20 mm, B = 5 mm, C = 2 mm, D = 2 mm. Photographed by T.-C. Hsu.

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AUTHOR CONTRIBUTION

Cheng-Wei Chen conceived the study, analysed the data and wrote a first draft of the paper. The authors who reviewed verified taxonomic data for each family are listed below: Cheng-Wei Chen (Athyriaceae, Cystodiaceae, Davalliaceae, Didymochlaenaceae, Diplaziopsidaceae, Dipteridaceae, Dryopteridaceae, Equisetaceae, Gleicheniaceae, Hypodematiaceae, Lomariopsidaceae, Lygodiaceae, Nephrolepidaceae, Oleandraceae, Ophioglossaceae, Osmundaceae, Plagiogyriaceae, Polypodiaceae, Psilotaceae, Pteridaceae, Saccolomataceae, Schizaeaceae, Selaginellaceae), Leon Perrie (Blechnaceae, Dennstaedtiaceae), Susan Fawcett (Thelypteridaceae), Alan Smith (Thelypteridaceae), Barbara Parris (Polypodiaceae), Atsushi Ebihara (Hymenophyllaceae), Daniel Ohlsen (Aspleniaceae), Samuli Lehtonen (Lindsaeaceae), Shi-Yong Dong (Tectariaceae), Marcus Lehnert (Cyatheaceae, Dicksoniaceae), Ashley Field (Lycopodiaceae), Yi-Shan Chao (Pteridaceae), Andrew Murdock (Marattiaceae), Michael Sundue (Selaginellaceae). Cheng-Wei Chen, Leon Perrie, and Wen-Liang Chiou compiled the life form data and distribution for each species. All authors provided comments and contributed to revisions.

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MONITORING OF A FOUNDER POPULATION OF THE HART'S TONGUE FERN (*ASPLENIUM SCOLOPENDRIUM*) ON A FORMER SEA-FLOOR (JAGERSVELD) OVER 34 YEARS (1985 – 2018).

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Keywords: Jagersveld, *Asplenium scolopendrium*, demography, long-term monitoring

ABSTRACT

Over a 34 year period a founding population of the Hart's Tongue Fern was monitored in the Jagersveld near Lelystad (reclaimed polder O.-Flevoland, 1957), a young woodland plantation on a former sea-floor with a sandy clayish soil. In 1985 there were only two individuals, but numbers increased sharply in the late 1990s and since 2005 has matched the national trend. The first cohort consisted of plants that established independently and subsequent recruitment was strongly related to these founding plants. The longevity of sporelings, juvenile and subadult plants proved to be 1.1, 1.6 and 1.7 years. Adults lived on average 4.4 years based on plants that completed their whole life cycle during the 34 years of monitoring. The half-life of the whole population was 4.5 years. Annual rainfall had a positive impact on the survival of adults, spring rainfall on the transition from juvenile to subadult. Severe winters had no impact, probably because winters became milder. Small-scale land-slips along the (dry) ditches and self–thinning were shown to be the most important factors in mortality. A further increase in population size is expected because of the increase in mild winters associated with climate change.

INTRODUCTION

In 1986 a study began on the population structure of a founder population of the *Asplenium scolopendrium* L. (Hart's Tongue Fern) with the aim to document the colonization history of this species. The study paralleled an extensive study on the demography of this species in the Kuinderbos (Bremer, 2007; Bremer & Jongejans 2010). The founder population started with only a few plants in 1985 and has been monitored for 34 years. Previous demographic studies usually cover a short period, although one in Sweden lasted 28 years (Tamm, 1972) and a study on orchids lasted 30 years (Willems, 2002). Demographic studies over a long period of time enable us to relate demographic parameters to changes in abiotic and biotic conditions. In the study of Bremer & Jongejans (2010) frost, litter and precipitation were shown to be factors that had a significant impact on survival.

MATERIALS AND METHODS

The Jagersveld (45 ha) was planted in 1965 in the vicinity of Lelystad (O.-Flevoland) (Figure 1). Before planting the bottom was ploughed and ditches dug with a density up to 1 km/ha. These ditches were on average 60–70 cm deep and filled with water only in wintertime. The soil consisted of a calcareous sandy clay. The upper tree layer was Poplar (*Populus ×canadensis*) and the lower tree layer Ash (*Fraxinus excelsior*), Bird cherry (*Prunus padus*) and Sycamore (*Acer pseudoplatanus*). Hawthorn (*Crataegus monogyna*), Hazel (*Corylus avellana*) and Dogwood (*Cornus sanguinea*) dominated the shrub layer. Since 1994 the woodland has been managed extensively without harvesting.

Numerous rare ferns have established in the Jagersveld including *Ophioglossum vulgatum* L. (Adder`s Tongue Fern) (Smit, 1989).

THE STUDIED SPECIES

Asplenium scolopendrium is a long-lived perennial fern species with gametophyte and sporophyte phases. This study focused on the sporophyte phase. *Asplenium scolopendrium* is a markedly calcicole, evergreen species, requiring habitats that are more or less permanently moist. It thrives on soils with a high pH and in mineral soils with very little humus (Page, 1982; Dostal et al., 1984). It can be abundant in mixed deciduous woodlands in the western part of the UK. In the Netherlands, *A. scolopendrium* is known as a wall-dwelling species, with terrestrial plants restricted to dunes with

Figure 1. The Jagersveld in O.-Flevoland (The Netherlands), the Kuinderbos and some Dutch cities are indicated together with woodland (green) and province boundaries.

calcareous sand (Weevers et al., 1948). In the early 1960s the first terrestrial *A. scolopendrium* established in the Kuinderbos (the Noordoostpolder), a large planted woodland on a former sea floor reclaimed from the IJsselmeer in 1941–1942 (Bremer, 2007). There has been a steep increase in the species in the Netherlands since 2000, attributed to climate change with the increase of mild winters and wet summers (Figure 2) and it is no longer restricted to calcium rich habitats.

DEMOGRAPHY

The demography was studied in woodland, where the species established at various sites. Plants were labelled individually (Figures 3, 4) and all localities mapped in detail. Annual monitoring took place over 34 years (1986 – 2018) between early August and mid-September each year, when sporangia of adult plants had ripened and sporelings had emerged; few new sporelings emerged during September. For each plant the number of fronds, number of fertile fronds and maximum length of a frond (plant height) were measured. The life stages and their definitions were based on Bremer & Jongejans (2010) (Table 1, Figure 5). During the annual survey causes of mortality were noted, e.g. when plants died due to small-scale erosion of the ditch sides. As the whole woodland was part of the census sometimes new adult plants were found, but these were not included as part of the demographic analysis. We constructed a 5 x 5 stage-structured transition matrix in which the columns gave the transitions from the five stages (Table 2). Each element of the transition matrix was defined by a combination of vital rates: s_j = survival rate of individuals in stage j; j = reproduction rate of adults; g_{ji} = growth rate of surviving individuals progressing from stage j to stage I; r_{ij} = retrogression rate of surviving individuals from j to i (i.e., shrinkage of plants to smaller-size classes or adults becoming

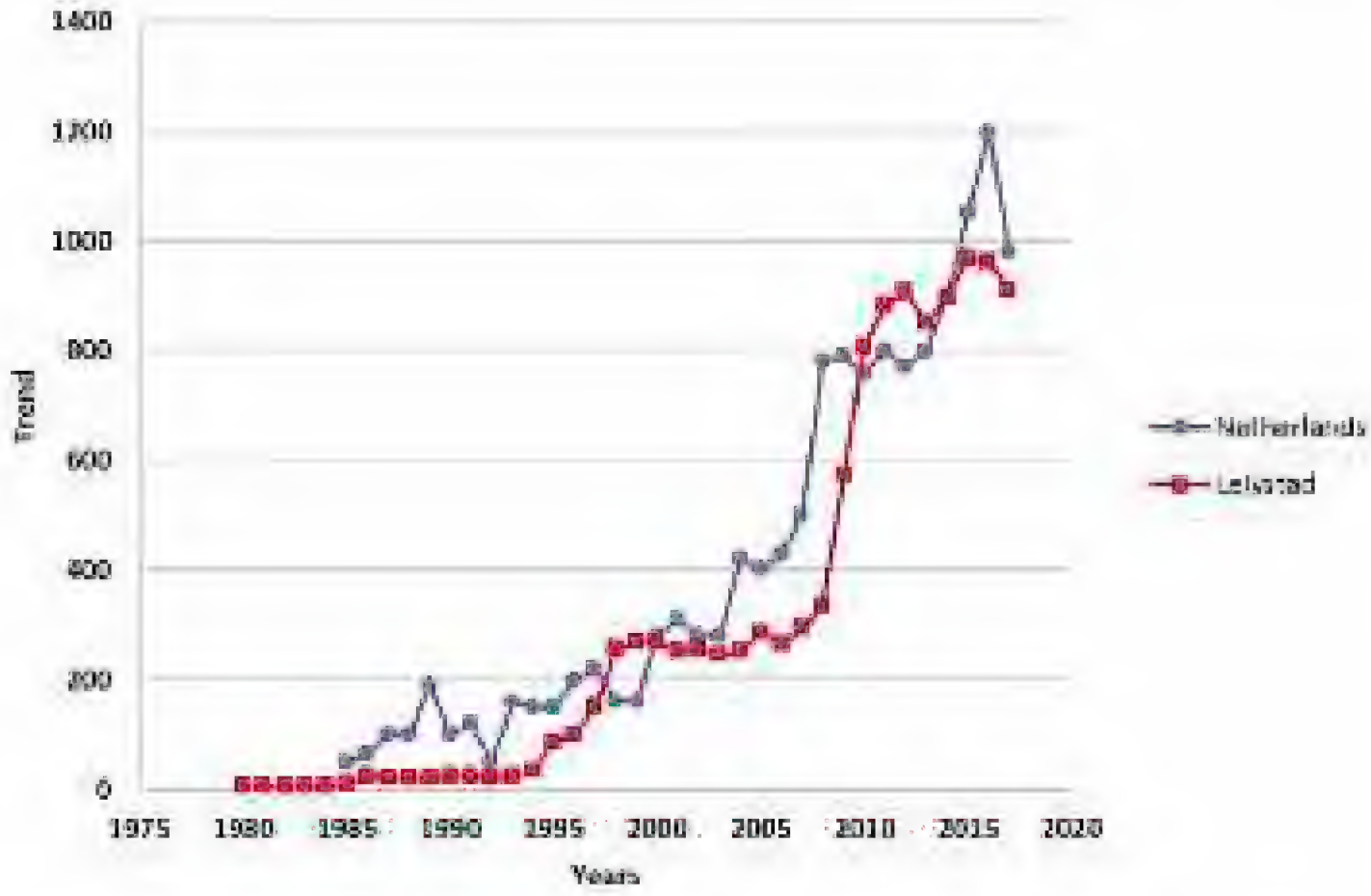

Figure 2. The trend of *Asplenium scolopendrium* in The Netherlands (1990, index = 100) (www verspreidingsatlas nl; NEM. CBS & Floron 2017) and at Lelystad (Jagersveld, 1996 index = 100).

Figure 3. Dry ditch side with labelled sporelings and juvenile plants of *Asplenium scolopendrium* (photo Piet Bremer).

Figure 4. A labelled juvenile plant (photo Piet Bremer).

post-adults). Adult reproduction was calculated by dividing the number of new sporelings in a plot by the number of adults in the previous year. Stasis, i.e., surviving plants remaining within the same class, was modelled as 1 minus the growth and retrogression rates of the surviving plants in that stage class. These notations for the different types of vital rates were similar to those used by Franco and Silvertown (2004) and Jongejans et al. (2006).

DATA ANALYSIS

The statistical package SPSS 24.0 was used for multiple regression, linear regression and correlations.

RESULTS

POPULATION SIZE

The first plant of *A. scolopendrium* was found at the Jagersveld in 1980, with four plants in 1986 (Figure 2). In the 1990s the numbers increased exponentially followed by subsequent decrease because of land-slip and mortality within the group of sporelings and juvenile plants. Also in the 1990s new plants were recorded at other sites within the woodland. Although the trends at all these sites were not the same, the overall trend showed a strong increase since the start of 2000. The trend in the Jagersveld population correlated strongly with that of the national trend ($r = 0.92$ $p < 0.01$) (Figure 2).

Table 1. The life stages of *Asplenium scolopendrium* according to Bremer & Jongejans (2010), with some adjustments (also see Figure 3).[1]

Life stages	Description
sporeling	small plant attached to the prothallus. maximum frond length < 2 cm
juvenile	plant with maximum frond length between 2 and 10 cm
subadult	plant with maximum frond length > 10 cm
adult	plant with at least one fertile fronds with ripe sori
vegetative adult	sterile plant being fertile in the preceding year
postadult	former adult plant unable to become adult again (period between adult stage and death).

[1] Bodziarczyk (2008) distinguished some more adult stages based on the number of fertile fronds.

Table 2. Transition matrix with vital rates – reproduction, stasis, regression and growth: σ = survival. ρ = regression. φ = reproduction. γ = growth (after Franco & Silvertown, 2004; Jongejans et al., 2006).

	sporeling	**juvenile**	**subadult**	**adult**	**vegetative adult**
sporeling	$\sigma_1 (1-g_{21}-g_{31})$	$\sigma_2 r_{12}$	$\sigma_3 r_{13}$	$\Phi(1-g_{24})$	
juvenile	$\sigma_1 g_{21}$	$\sigma_2(1- r_{12}- g_{32} - g_{42})$	$\sigma_3 r_{23}$	φg_{24}	
subadult	$\sigma_1 g_{31}$	$\sigma_2 g_{32}$	$\sigma_3(1- r_{13}- r23_- g_{43})$		
adult		$\sigma_2 g_{42}$	$\sigma_3 g_{43}$	$\sigma_4 (1-r_{54})$	$\sigma_5 \gamma_{45}$
vegetative adult				$\sigma_4 r_{54}$	$\sigma_5 (1-\gamma_{45})$

Figure 5: The life stages of *Asplenium scolopendrium*.
a: sporelings, b: juveniles, c: subadults, d: adults

Table 3. Vital rates for the Jagersveld population in the period 2009 – 2018. 9 = 2009-2010. 10 = 2010-2011 etc., av = average of 9 years.

		9	10	11	12	13	14	15	16	17	av
Reproduction: the number of sporelings$_{t+1}$ per adult $_t$	**φ**	14.8	4.6	0.62	0.45	0.28	0.27	0.34	0.37	0.001	2.41
Survival of sporelings	σ_1	0.98	0.9	0.43	0.9	0.92	0.88	0.73	0.71	0.05	0.72
Survival of juveniles	σ_2	0.92	0.92	0.99	0.69	0.81	0.77	0.76	0.74	0.56	0.80
Survival of subadults	σ_3	1	1	0.95	0.92	0.96	0.91	0.91	0.9	0.54	0.90
Survival of adults	σ_4	1	1	1	0.91	0.86	0.96	0.89	0.91	0.77	0.92
Survival of postadults	σ_5	1	1	1	0.66	1	1	1	0.96	0.97	0.95
Survival of all life stages	**σ**	0.96	0.91	0.82	0.82	0.93	0.91	0.81	0.84	0.96	0.84
Growth from sporeling to juvenile$_{t+1}$	γ_{21}	0.79	0.96	0.77	1	0.91	0.02	0.5	0.62	1	0.73
Reproduction from adult to juvenile $_{t+1}$	γ_{24}	0.42	0	0	0.1	0.09	0.07	0.07	0.14	0	0.10
Growth from sporeling to sub-adult$_{t+1}$	γ_{31}	0.02		0	0	0	0	0	0.1	0	0.02
Growth from juvenile to sub-adult $_{t+1}$	γ_{32}	0.18	0.59	0.44	0.6	0.59	0.4	0.32	0.15	0.07	0.37
Growth from juvenile to adult $_{t+1}$	γ_{42}	0	0.37	0.07	0.1	0	0.05	0	0.1	0	0.08
Growth from sub-adult$_t$ to adult$_{t+1}$	γ_{43}	0.67	0.6	0.59	0.51	0.54	0.48	0.19	0.39	0.14	0.46
Growth from post-adult t to adult $_{t+1}$	γ_{45}	0	0	0	0.5	1	1	0.22	0.19	0.18	0.34
Growth for all life stages	**γ**	0.51	0.46	0.45	0.45	0.28	0.17	0.22	0.22	0.1	0.32
Retrogression from juvenile$_t$ to sporeling$_{t+1}$	ρ_{12}	0.03	0.01	0	0	0.05	0.05	0.14	0.1	0	0.04
Retrogression from sub-adult$_t$ to sporeling$_{t+1}$	ρ_{13}	0	0	0	0	0	0	0.05	0.06	0	0.01
Retrogression from sub-adult$_t$ to juvenile$_{t+1}$	ρ_{23}	0.33	0	0	0.02	0.05	0.03	0.14	0.06	0	0.07
Retrogression from adult$_t$ to post-adult$_{t+1}$	ρ_{54}	0	0	0.11	0.02	0.01	0.08	0.18	0.3	0.31	0.11
Retrogression for all life stages	**ρ**	0.03	0.01	0.01	0.01	0.02	0.07	0.19	0.19	0.14	0.07

LONGEVITY

The average age of sporelings was 1.1 years (± 0.3), juveniles 1.6 years (±1.1), subadults 1.7 years (± 0.7) and adults 4.4 years (±1.5). All plants recorded from the first cohort in the 1980s (n = 7) disappeared before 2018. The maximum age of an individual was 32 years.

TRANSITIONS

Transition have been analysed for the period 2009 – 2018 with a minimum of 100 transitions (Table 3). There is a positive correlation between survival of adults and the sum of annual rainfall and with the number of frost days (Table 4). The Atlantic *A. scolopendrium* benefits from wet years, although wet April months have a negative impact on the transition from juvenile to adult while frost had a positive effect on the juvenile to adult transition. Rainfall in May and June had a negative impact on the transition from subadult to adult. The survival of adults (σ4) is correlated with the annual

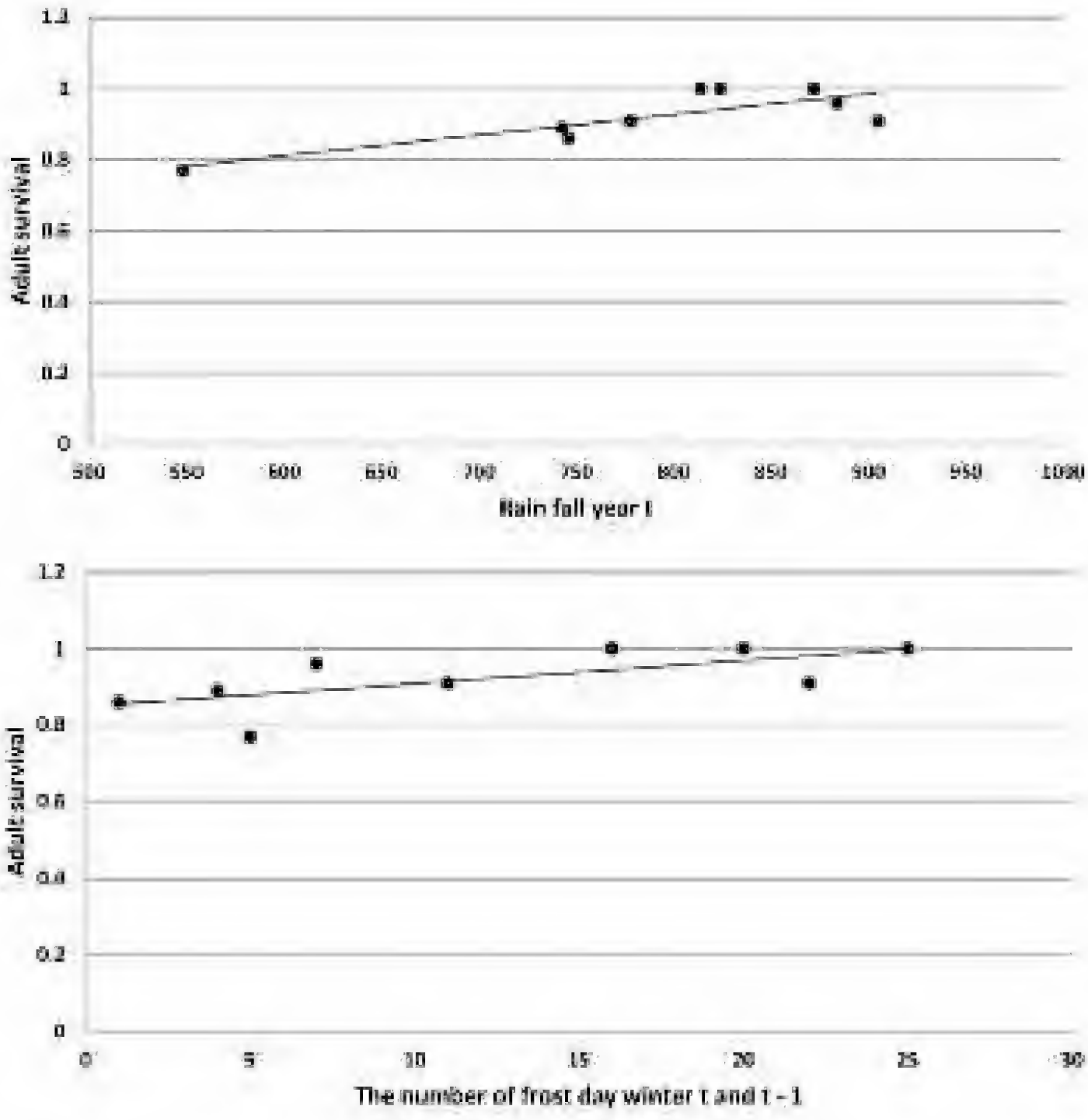

Figure 6. The impact of the climate on the survival of adults (σ4).
a. annual rainfall,
b. the number of frost days per winter (year t and year t – 1).

rainfall and number of frost days per year. A multiple linear regression model showed that both parameters contributed 74% to survival.

COMPARISON OF THE JAGERSVELD AND THE KUINDERBOS

In the Jagersveld it took 4.9 years before sporelings became adult plants with an average plant height of 24.6 cm in the fifth year after germinating; these results were similar to data from the Kuinderbos (a *Picea sitchensis* and *Fraxinus excelsior* plot), although the average number of fronds in the fifth year is higher in the Jagersveld than in the Kuinderbos plots. Nine plants in the Jagersveld reached a maximum frond length of at least 75 cm at an average age of 20 years (n = 480 monitored plants over 34 years). The largest plant had 38 fronds and maximum frond length of 83 cm. It was 32 years old when it died from an unknown reason.

MORTALITY

The most important causes of mortality were land-slip in dry ditches, density – dependent mortality due to crowding of plants at all stages leading to self-thinning, and drought. Land-slip of ditch banks was caused by strong rainfall, burrowing activity of mice or stress from other animals. Sporelings or juveniles were often transported by land-slips

Table 4. Correlation between vital rates and rainfall: rain MJ = rainfall in May–June in year t; rain At = rainfall April in year t; rain AMt = rainfall April-May in year t; rain Yt = rainfall in year t. nFr t-1/t = the number of days with frost in winters year t and t – 1, * **p < 0.05** ** **p < 0.01**. The rate symbols are explained in Table 3.

Rates	rain MJt	rain At	rain AMt	rain Yt	nFr t-1/t
φ	-0.228	-0.161	-0.320	0.164	0.336
σ1	0.390	-0.593	0.051	0.589	0.212
σ2	0.484	-0.327	0.296	0.643	0.495
σ3	0.632	-0.528	0.329	**.783***	0.414
σ4	0.343	-0.626	-0.016	**.811****	**.677***
σ5	-0.116	0.163	-0.023	0.072	-0.388
σ	0.435	-0.562	0.113	**.761***	0.240
γ21	0.254	0.179	0.355	-0.490	0.356
γ24	-0.321	-0.014	-0.328	0.250	0.038
γ31	0.061	-0.358	-0.104	0.442	0.068
γ32	.723*	-0.442	0.470	0.253	0.359
γ42	0.532	**-.783***	0.083	0.287	**.704***
γ43	0.326	-0.581	-0.007	0.636	0.601
γ45	0.272	0.215	0.395	-0.153	-0.490
γ	0.453	-0.377	0.236	0.407	**.814****
ρ12	0.150	0.195	0.261	0.199	-0.550
ρ13	0.193	0.143	0.275	0.214	-0.292
ρ23	-0.278	0.176	-0.177	0.126	-0.076
ρ54	-0.369	0.448	-0.112	-0.312	-0.423
ρ	-0.267	0.387	-0.045	-0.202	-0.563

within the ditch habitat and died because of root damage. The percentage of self-thinning in the Jagersveld matched data from the Kuinderbos. Drought played a more important role in the Jagersveld than in the Kuinderbos where a thick layer of peat guaranteed the water supply. Frost damage had little effect at the Jagersveld, but in contrast there were a number of severe winters in the Kuinderbos.

DISCUSSION

Long-term demographic studies are very rare with studies based on a complete woodland unknown previously. Within the Netherlands long-term studies are restricted to some orchid species (Willems, 2002), where *Spiranthes spiralis* and *Orchis simia* monitoring also started with small founding populations. Bremer (2007) monitored *A. scolopendrium* for 20 years but the study was focused on plots. Bodziarczyk (1992) and Cinquemani & Leopold (1992) studied *A. scolopendrium* over shorter periods. In this present study over the last 10 years there have been more than 100 transitions that facilitated a transition analysis. Subpopulations within the woodland were not taken into account but lumped. Colonisation showed two phases, with the first in the 1990s and a second wave after 2005. These data strongly match national data (www.verspreidingsatlas.nl), indicating a positive trend in the Netherlands. De Groot (2011) showed that after establishment of an adult plant a shadow of sporelings developed following intragametophytic mating, with different genetic clusters related to colonization of independent adult plant in

Table 5. Population parameters compared between the Jagersveld and the Kuinderbos (Bremer & Jongejans, 2010). The periods match for over 15 years (1985 – 1999).

	Jagersveld	**Kuinderbos**		
		Sitka	Beech*	Ash
Number of years with monitoring	34	20	21	7
Periods	1985-2018	1989-1998	1978-1999	1983-1990
Survival				
n	299	114	299	161
Half life	4.5	1.7	1.8	2.8
Fertility				
n	116	11	13	21
The number of years before coming an adult	3-13	3-10	4-8	3-6
Age (at average) plants become adults	4.9	4.5	6.3	4
Vitality				
n	91	**	**	**
Height in the fifth year	24.6	17.6	9	31.3
Frond number in the fifth year	7.7	3.9	4.1	7.1

* PF2 in Bremer & Jongejans, 2010. ** numbers not listed by Bremer & Jongejans, 2010.

different parts of the Kuinderbos.

Before 1990 *A. scolopendrium* was a rare species of old canal walls in the Netherlands. Since 2020 there has been a positive trend, with plants growing in a wide range of habitats, less confined to a calcareous habitat and appearing in sandy and loamy sites devoid of calcareous deposits. The results from the Jagersveld match the national trend, but differ from the Kuinderbos, where already by 1985 more than 1000 plants had been recorded, confined to this area with a high density of dry ditches with calcareous deposits, a peaty spongy subsoil and a dense canopy, together providing an optimal habitat not only for *A. scolopendrium*, but for other ferns too (Bremer, 2007). The national increase and increase at the Jagersveld coincides with higher winter temperatures. It has been shown that *A. scolopendrium* is susceptible to low winter temperatures that cause frost damage, often resulting in adults becoming sterile in the subsequent year, higher mortality of sporelings and limited growth (Bremer & Jongejans, 2010). However, data on the effect of frost at the Jagersveld showed the opposite effect, which is hard to explain although during the period of monitoring there were no severe winters. Severe and mild winters alternated in the Kuinderbos study. The positive effect of rainfall on adult survival at the Jagersveld matched that of the Kuinderbos.

When comparing fertility and vitality, plant height and age of transition from subadult to adult, the Jagersveld data are within the range of the Kuinderbos data. These are lower compared with a plot at an Ash stand, but higher for a plot in a Beech stand, factors that may to be related to the light regime. At the Jagersveld Ash played an important role in the canopy, but the lower tree and shrub layer e.g. with *Prunus padus* and *Crataegus monogyna*, caused more light interception compared with the Kuinderbos Ash plot, where there was no secondary tree and shrub layer. Light in woodlands has an impact on growth and fertility but also on the micro distribution of individual plants (Ellenberger & Leuschner, 2010). Bodziarczyk & Krzus (2006) measured plants from populations in the Pininy National Park in Poland and found a maximum frond length of 54 cm. Within the Atlantic climate zone plants produce longer fronds, as reported by Bremer (2021) who surveyed 50 sites from seven European countries and measured 2300 plants, with a few reaching a frond length of 80 cm. During the extensive and long term study in the Kuinderbos only once was a plant found with a frond length of 90 cm.

The results on mortality at the Jagersveld match those from the long-term study at

Table 6. Causes for mortality at the Jagersveld compared with the Kuinderbos (Bremer, 2007). ? = not studied in detail.

	Jagersveld (Lelystad)	%	Kuinderbos	%
Population size	228		616	
Period	1985 - 2018		1978 - 1999	
Frost	?		192	31.2
Self thinning	40	15.2	108	17.5
Land slide	60	26	39	6.3
Litter accumulation	-		14	2.3
Herbivory	?		1	0.2
Drought	35	15	1	0.2
Drowning	3	1.3	-	
Factors unknown	90	57.5	261	42.3

the Kuinderbos, with small-scale land-slip of dry ditch banks and self-thinning playing an important role. Land-slip is often related to heavy rain fall and bryophytes and woodland herbs are not able to prevent this erosion. Self-thinning has been reported from tree recruitment and agricultural studies that start with high densities of young plants but within wild populations, with a mixture of species and individuals, self-thinning is less obvious. *Asplenium scolopendrium* has become dominant in the dry ditches of the Kuinderbos after mass recruitment and self-thinning, although frost strongly reduced the population growth, causing death, stunting or increasing sterility. This effect was not seen in the Jagersveld study as there were few years with severe frost.

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DRYOPTERIS CARPATICA SPEC. NOV. – A TETRAPLOID SPECIES OF THE *DRYOPTERIS AFFINIS* AGGREGATE (DRYOPTERIDACEAE, POLYPODIOPSIDA) FROM THE SOUTHERN CARPATHIANS

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Keywords: *Dryopteris affinis* agg., cytology, flow cytometry, PgiC gene

ABSTRACT

A new tetraploid species of the *Dryopteris affinis* aggregate is described from the Romanian Carpathians. Results of flow cytometric, cytological and molecular genetic investigations are discussed.

ZUSAMMENFASSUNG

Aus den rumänischen Südkarpaten wird eine neue, tetraploide Art des *Dryopteris affinis*-Aggregats beschrieben. Die Resultate durchflusszytometrischer, karyologischer und molekulargenetischer Untersuchungen werden diskutiert.

INTRODUCTION

Representatives of the *Dryopteris affinis* aggregate (Scaly Male Fern) are not rare in the mountain forests of the Southern Carpathians and the Făgăraş Mountains of Romania, and are often more common there than the widespread *D. filix-mas* (L.) Schott. The diversity of *D. affinis* s.l. in this area was already recognised by Jeßen (1985, 1991), and included *D. affinis* (Lowe) Fraser-Jenk. subsp. *affinis* var. *disjuncta* (Fomin) Fraser-Jenk. and *D. borreri* (Newman) Newman ex Oberh. & Tavel., both widespread in Euope, and further specimens which could not be assigned to any previously described taxa. One such taxon, *D. affinis* subsp. *borreri* var. *splendens* in Jeßen (1985) and provisionally *D. affinis* subsp. *affinis* var. ined. in Jeßen (1991), has meanwhile been described as *D. affinis* subsp. *jessenii* Fraser-Jenk. (Widén et al., 1996, Fraser-Jenkins, 2007). A further taxon from the Făgăraş Mountains was initially thought to be *D. schorapanensis* Askerov (syn. *D. affinis* subsp. *persica* Fraser-Jenk.) known from the Caucasus region, northeastern Anatolia and Iran (Jeßen, 1991). This taxon from the Făgăraş Mountains differs from *D. filix-mas* in having highly hemispherical indusia before spore maturity, more scaling of the petiole, and the suggestive violet-black attachment sites of the pinnules to the rachis. Thus, it is very similar to the hybrid *D.* ×*complexa* Fraser-Jenk. nothosubsp. *complexa* (*D. affinis* subsp. *affinis* × *D. filix-mas*), which has also been recorded in this area (Jeßen, 1991). However, as the frequency of individuals in nature shows and culture experiments confirm, the spores are predominantly formed normally and a high proportion of them are capable of germination. The taxon occurs in large

populations, apparently growing in a specific habitat in the montane and high montane zone and it merits recognition as a new species.

MATERIAL AND METHODS

For comparative purposes, living material of diverse representatives of the *Dryopteris affinis* aggregate and other *Dryopteris* species growing in the Arctic-Alpine Garden in Chemnitz and the garden of W. Bujnoch as well as herbarium material of various provenances from the collections of W. Bujnoch, S. Jeßen, G. Zenner and T. Reichstein were used:

D. affinis (Lowe) Fraser-Jenk. subsp. *affinis* var. *affinis*: SJ-1025: Azores, São Miguel, 650 m a.s.l., plant from T. Reichstein (TR-3548); SJ-2328: S-France, Cevennes, Luechtal near Chareneuve, ca. 290 m a.s.l., leg. S. Jeßen, C. Stark & G. Zenner 10.08.1993; SJ-3870: NE Turkey, Prov. Rize: Çimil valley near Ikizdere, ca. 770 m a.s.l., leg. S. Jeßen 11.09.2011; SJ-4029: Madeira, Lombo de Fajas, NW of Santo Antonio da Serra W. Machico, above Portela, 640 m a.s.l., leg. G. Zenner 14.04.1995 (Dr.1, GZ-106); plant from W. Bujnoch 2017 (GWBT150, NZ WB FZ-95/22)
D. affinis subsp. *affinis* var. *disjuncta* (Fomin) Fraser-Jenk.: SJ-137: Romania, Southern Carpathians, N-Făgăraş, hotel Bâlea Cascada, approx. 1000 m a.s.l., leg. S. Jeßen 16.08.1982; SJ-2950: Germany, Alpine foothills south of Munich: Urlaine valley near Eschenlohe, approx. 720 m a.s.l., leg. S. Jeßen & L. Lehmann 03.10.1996; SJ-3175: Germany, Saxon Switzerland: Gohrisch, approx. 370 m a.s.l., leg. L. Lehmann 05.07.1999; SJ-3998: Germany, Thuringia, Herrnberg W Neuhaus a.R., 819 m a.s.l., leg. S. Jeßen & L. Lehmann 16.11.2015
D. affinis subsp. *jessenii* Fraser-Jenk.: SJ-139: Romania, N-Făgăraş, Bâlea Valley, approx. 1000 m a.s.l., leg. S. Jeßen 15.08.1982; SJ-1305/SJ-1306: Romania, N-Făgăraş, Şerbota Valley SSO Porumbacu de Sus, approx. 600 m a.s.l., leg. S. Jeßen 01.08.1985
D. affinis subsp. *punctata* Fraser-Jenk.: SJ-3799: Switzerland, Canton Schwyz: Hüllerichwald ob Pfäffikon, 500 m a.s.l., leg. M. Rauch, F. Mokry & T. Reichstein 09.08.1982 (TR-5732); SJ-3942: Switzerland, Canton Zurich: above Hütten, Hoher Rohn, approx. 950 m a.s.l., leg. E. Oberholzer 03.10.1962, plant from T. Reichstein (TR-740)
D. ardechensis Fraser-Jenk.: SJ-1369: S-France, Cevennes, Dep. Ardeche, Pont de Labeaume, leg. C.R. Fraser-Jenkins 17.01.1972 (CRFJ-3602), plant from T. Reichstein (TR-3443); SJ-2327/1: S-France, Cevennes, Dep. Gard, Luech valley near Chamboredon, approx. 210 m a.s.l., leg. S. Jeßen, C. Stark & G. Zenner 10.08.1993
D. borreri (Newman) Oberh. & Tavel: SJ-141: Romania, N-Făgăraş, Bâlea Valley on the Trans-Făgăraş Road, leg. S. Jeßen 15.08.1982; SJ-144: Germany, Thuringia, Gera, Türkengraben near Dürrenebersdorf, approx. 280 m a.s.l., leg. S. Jeßen 06.05.1983; SJ-166: Germany, Thuringia, Waldecker Schlossgrund near Bürgel, approx. 270 m a.s.l., leg. S. Jeßen 1974, SJ-169: Bulgaria, Pirin, Brezniška reka valley, approx. 1050 m a.s.l., leg. S. Jeßen 30.06.1976; SJ-170: Czech Republic, Moravian Karst, SW Dolni Lotha near Blansko, approx. 500 m a.s.l., leg. S. Jeßen 20.07.1977; SJ-369: Germany, Sachsen-Anhalt, Harz, Bodetal, approx. 400 m a.s.l., leg. S. Jeßen 17.06.1984; ML1: Germany, North Rhine-Westphalia, District of Siegen-Wittgenstein, town of Kreuztal, mining desert Altenberg am Ziegenberg east of Littfeld, approx. 460 m a.s.l., leg. M. Lubienski 01.07.2014
D. cambrensis (Fraser-Jenk.) Beitel & W.R.Buck subsp. *insubrica* (Oberh. & Tavel ex

Fraser-Jenk.) Fraser-Jenk.: SJ-145: Germany, Thuringia, Gera, Fuchsgraben near Wolfsgefärth, 270 m a.s.l., leg. S. Jeßen 17.07.1982; SJ-163: Germany, Thuringian Forest, Schmidtsbruch near Steinach, approx. 600 m a.s.l., leg. S. Jeßen 24.08.1980; SJ-3674: Switzerland, Bernese Oberland, Urbachtal near Innertkirchen, approx. 950 m a.s.l., leg. S. Jeßen 02.07.1995; SJ-3965: Germany, Baden-Wuerttemberg, Felsenmeer O Heidelberg, 380 m a.s.l., leg. A. König & M. Sonnenberger 07.10.2012

D. cambrensis subsp. *pseudocomplexa* Fraser-Jenk. [= *D. pseudocomplexa* (Fraser-Jenk.) P.D.Sell]: SJ-4006: Great Britain, Scotland: Isle of Arran, SW Lochranza; leg. G. Zenner 15.08.1996 (Dr 36)

D. carpatica: SJ-136: Romania: N- Făgăraş, Bâlea valley under the hotel "Bâlea Cascada", 1225 m a.s.l., leg. S. Jeßen, W. Meusel, J. Müller & H. Pöhlmann 16.08.1982; SJ-1307: Romania, N- Făgăraş, around the hut "Negoiu" SSO Porumbacu de Sus, 1545 m a.s.l., leg. S. Jeßen & J. Müller 03.08.1985; SJ-1308: Romania, N- Făgăraş, around the Şerbota Cascada waterfall below the "Negoiu" hut, approx. 1300 m a.s.l., leg. S. Jeßen 03.08.1985

D. ×complexa Fraser-Jenk.nothosubsp. *complexa*: SJ-1309: Romania, N- Făgăraş, Şerbota Valley SSO Porumbacu de Sus, approx. 1000 m a.s.l., leg. S. Jeßen 05.08.1985; SJ-2091: Germany, Allgäu, Grünten, SW slope, between 950 and 980 m a.s.l., leg. A. Eschelmüller & S. Jeßen 12.07.1990; SJ-3012: Switzerland, Bernese Oberland, Urbachtal near Innertkirchen, under Dirreschwand, 1030 m a.s.l., leg. S. Jeßen, C. Stark & G. Zenner 10.08.1998

D. ×complexa nothosubsp. *eschelmuelleri* Fraser-Jenk.: SJ-2816: Germany, Bavaria, Allgäu, Maisach headwaters at Scheidegg, approx. 860 m a.s.l., leg. A. Eschelmüller 15.10.1983, plant from A. Eschelmüller 1991; SJ-2135: Austria, Valschavieltal, approx. 1100 m a.s.l., leg. A. Eschelmüller & S. Jeßen 20.07.1991 (=AE 91/44); SJ-2136: Austria, Valschavieltal, approx. 1300 m a.s.l., leg. A. Eschelmüller & S. Jeßen 20.07.1991

D. ×complexa nothosubsp. *transsilvanica* Tlalka, S.Jess., A.Rostański & Rojek: SJ-1303: Romania, N-Făgăraş, Şerbota Valley SSO Porumbacu de Sus, 580 m a.s.l., leg. S. Jeßen 01.08.1985; SJ-1310: Romania, N- Făgăraş, Şerbota Valley SSO Porumbacu de Sus, approx. 750 m a.s.l.; leg. S. Jeßen 05.08.1985

D. ×critica (Fraser-Jenk.) Fraser-Jenk.: SJ-201: Germany, Thuringia, Jena, Waldecker Schloßgrund near Bürgel, approx. 270 m a.s.l., leg. S. Jeßen 29.09.1984; SJ-1291: Germany, Thuringia, Uhlschegrund near Uhlstädt, approx. 250 m a.s.l., leg. S. Jeßen 22.06.1985

D. filix-mas (L.) Schott: SJ-2818: Germany, Saxony, Zschopautal, Schlossberg Lichtenwalde near Chemnitz, approx. 280 m a.s.l., leg. S. Jeßen 1975; SJ-3676: Czech Republic, Altvater Mountains, Big Cauldron, leg. W. Meusel & H. Pöhlmann 1976; SJ-3794: Bulgaria, Rila Mountains, "partisan meadow", leg. W. Meusel, J. Müller & H. Pöhlmann 1974

D. lacunosa S.Jess., Bujnoch, Zenner & Ch.Stark: SJ-2166: Switzerland, Ticino, Piandessio near Bellinzona, 360 m a.s.l., leg. S. Jeßen 26.07.1991; SJ-2262: Switzerland, Bernese Oberland, Innertkirchen near Meiringen, path to Loibalp above Unterstock, approx. 960 m a.s.l., leg. S. Jeßen 20.07.1992; SJ-2953: Switzerland, Ticino, Osogna Gorge, approx. 510 m a.s.l., leg. S. Jeßen, E. Kopp, K. Rasbach & P. Vogel 16.07.1990; SJ-3011: Switzerland, Bernese Oberland, Innertkirchen, Urbachtal near Unterstock, 1020 m a.s.l., leg. S. Jeßen, C. Stark & G. Zenner 10.08.1998

D. pseudodisjuncta (Tavel ex Fraser-Jenk.) Fraser-Jenk.: SJ-386: Germany, Oberallgäu, Immenstadt, 800-900 m a.s.l., leg. A. Eschelmüller 08.09.1984 (AE-84/49), aus Sporen

von 1986; SJ-3465: Switzerland, Zuger Berg south of Zurich, leg. S. Jeßen bei Exk. mit der SVF 02.09.1989
D. schorapanensis Askerov: SJ-1028: Iran, Herowabad, Talesh, Gilan, W of Siādûn, 200 m a.s.l., leg. C.R. Fraser-Jenkins 17.08.1973 (CRFJ-3948), plant from T. Reichstein (TR-3712) 1993; SJ-2954: Iran, Prov. Gilan, Lasak valley side valley of Kash-e khalek, 5 km from Emamzadek Ebrahim, 750-1000 m a.s.l., leg. P. Wendelbo & M. Assadi 19.7.1976, plant from T. Reichstein (TR-4434) 1993.

FLOW CYTOMETRY (J. Fuchs)
For flow cytometric estimation of DNA content approximately 0.5 cm^2 of young frond tissue was chopped together with appropriate amounts of leaf tissue from one of the reference standards, *Pisum sativum* L. subsp. *sativum* convar. *sativum* var. *ponderosum* Alef., Sorte Viktoria, Kifejtö Borsó (IPK Genebank accession number: PIS 630; 9,07 pg/2C), *Hordeum vulgare* L. convar. *vulgare* var. *hybernum* Viborg, Sorte Hohenfinower (IPK Genebank accession number: HOR 82; 10,36 pg/2C) or *Secale cereale* subsp. *cereale* (IPK Genebank accession number: R 737, 16,01 pg/2C), with a sharp razorblade in a Petri dish in nuclei isolation buffer (Galbraith et al., 1983) supplemented with 1% PVP, 0,1% Triton X-100, DNase-free RNase (50 µg/ml) and propidium iodide (50 µg/ml). The resulting nuclei suspension was filtered through a 50 µm filter mesh (CellTrics, Sysmex-Partec) and subsequently measured on a CyFlow Space flow cytometer (Sysmex-Partec) or, in the case of *D. borreri* (ML1), on a FACStar^{PLUS} cell sorter (BD Biosciences). For each accession we measured four samples, except for SJ-136, SJ-1307/1 and SJ-2091 where only two and three samples were measured, respectively. Based on the values of the G1 peak means of the sample and the reference standard the absolute DNA contents of the taxa were calculated.

CYTOLOGY (W. Bujnoch)
To study meiosis and mitosis, young sporangia and fresh root tips of a plant (SJ-1307/1) cultivated in the Arctic-Alpine Garden Chemnitz were fixed in 3:1 ethanol/glacial acetic acid and squash preparations made following the method described by Manton (1950). A Zeiss photomicroscope equipped with high-aperture phase contrast objectives and a photo documentation device was used to study meiosis and mitosis.

MOLECULAR GENETICS (W. Bujnoch)
To study *Dryopteris carpatica* (SJ-136) at the nuclear PgiC gene (cytosolic 6-Phosphoglucoseisomerase), individual fragments were generated and their lengths compared. The intron between exons 15 and 16 proved especially suitable for comparison as it shows a species-specific length for a number of species of the genus *Dryopteris* (Juslén et al., 2011, Freiganget al., 2013, Bujnoch, 2015). For this fragment Ishikawa et al. (2002) constructed an 'EPIC'- primer pair (Exon Primed Intron Crossing), which offers almost general applicability. Due to a high frequency of poor PCR yields or complete PCR failures, the method described in Freigang et al. (2013) was replaced in part by the PCR-direct method of ThermoScientific (Phire Plant Direct PCR Kit, F-130WH). This method worked without DNA isolation and PCR yields were often higher. According to the manufacturer's instruction the workflow consisted of only two steps: 1. A disc of 0.3-0.5 mm diameter was punched out from fresh or silica gel-dried leaf material and put into PCR-solution. 2. PCR was performed according to the manufacturer's instruction. The uncleaned amplicon was genotyped in a sequencer (ABI

3500, Applied Biosystems or MegaBace Instrument, Healthcare). Employment of different sequencers made transformation of results necessary (marked with an asterisk). The analysis of the generated data was first made with Fragment Profiler software (Healthcare), then later with GeneMapper software (Applied Biosystems). Sometimes the sequencing device produced a double peak in consecutive base pairs (bp). This could be an artefact or may be the result of the used PCR-conditions. The relative height of signals within an electropherogram depended firstly on the number of sets of chromosomes causing the signal and, secondly, on the relative PCR yield of the 15/16-fragment of the existing alleles.

RESULTS

Comparison with other representatives of the *D. affinis* agg. revealed that *D. carpatica* is most similar to *D. borreri* and especially *D.* ×*complexa* nothosubsp. *complexa* (see Table 1 and Figures 1, 2). However, unlike the hybrids *D.* ×*complexa* nothosubsp. *complexa*, *D.* ×*complexa* nothosubsp. *eschelmuelleri* (*D. affinis* subsp. *punctata* × *D. filix-mas*) and *D.* ×*critica* (*D. borreri* × *D. filix-mas*), the mature sori of *D. carpatica* do not have largely failed sporangia or predominantly aborted spores (see Figures 3, 4). Although the spore mass contains some aborted material, the frequency of good spores is similar to that seen in other apomictic species such as *D. ardechensis*, *D. borreri* and *D. lacunosa* (see Figure 4).

Karyological and flow cytometric investigations showed the new taxon to be tetraploid (Figures 5, 6, 7; Table 2). This corrects an earlier result (Jeßen, 1991), where it was recorded as triploid, an error resulting probably from mis-interpretation of a meiotic cell with 123 units; these had been identified as bivalents, and the cell assumed to be a spore mother cell of the 8-cell type. However, a meiotic cell of the 16-cell type also results in a total number of 123 units, i.e. 41 bivalents and 82 univalents (see Figure 7).

The tetraploid state (see Table 2) distinguishes *D. carpatica* from the morphologically similar but triploid species *D. schorapanensis* from the Caucasus region, *D. borreri* which is widespread in Europe and also occurs in the Southern Carpathians, *D. cambrensis*, *D. lacunosa* (Jeßen et al., 2011) and *D. pseudodisjuncta*.

Chromosome pairing in meiosis of a spore mother cell of the 16-cell type revealed 42 bivalents and 80 univalents in one plant (SJ-1307/1) (Figure 7). This shows that meiosis does not proceed normally as in a sexual tetraploid species (e.g. *D. filix-mas*), forming 82 chromosome pairs, but is disturbed, as manifested by the proportion of aborted spores, and that this taxon is an apomict. Various morphological features, such as the domed indusia and the dark coloration attachment sites of the pinnae stalks, indicate that the taxon belongs to the *D. affinis* aggregate.

The origins of apomixis and the characteristic violet-black colour of the pinna attachment found in most representatives of the *D. affinis* aggregate are unknown (Fraser-Jenkins, 1980; Fraser-Jenkins & Reichstein, 1984; Fraser-Jenkins, 2007), but are ascribed to an unknown taxon that is also believed to be ancestral to the tropical-subtropical-montane *D. wallichiana* complex (Widén et al., 1996), and has been referred to as "*Dryopteris semiaffinis*" (Krause, 1998; Bujnoch, 2015; Freigang et al., 2017). Furthermore, the results of karyological and biochemical studies suggest that *D. oreades* Fomin and *D. caucasica* (A. Braun) Fraser-Jenk. & Corley are also parental taxa of the *D. affinis* aggregate (Manton, 1950; Fraser-Jenk. & Reichstein, 1984; Widén et al., 1996; Bär & Eschelmüller, 2014).

Table 1. Differentiation of *Dryopteris carpatica* from the similar taxa *D. borreri* and *D.* ×*complexa* nothosubsp. *complexa*.

Characteristics	***D. borreri***	***D. carpatica***	***D.* ×*complexa* nothosubsp. *complexa***
Scales on the middle rachis	mostly monochrome brown to light brown, more rarely with a dark brown base	brown to light brown, often with a dark brown base	light brown with a dark brown base
Scales on the pinnate spindles	mostly monochrome brown to light brown, more rarely with a dark brown base	mostly monochrome brown to light brown, rarely with a dark brown base	mostly monochrome light brown
Peduncles of the middle pinna	1.5–4 mm long, mostly distinctly violet-black	1–3 mm long, not or only slightly violet-black	1.5–4 mm long, not or only slightly violet-black
middle pinnate segments of the middle pinna	slightly lobed at the edge, usually only incised, often somewhat wavy, with broad, short teeth at the end	Somewhat lobed or toothed at the edge, not wavy, at the end with broad, short teeth or almost imperforate	Somewhat lobed or toothed at the edge, not wavy, with small, short teeth at the end
Indusia	initially hemispherical, not tearing from the edge, glandless; shrinking after spore ripeness, rising up like a funnel and often sloping	initially hemispherical, sometimes tearing from the edge, rarely with isolated glands; after the spore ripeness shrinking and funnel-shaped, but mostly not sloping	initially broadly arched, partly with an outwardly curved, thin edge, often tearing from the edge, glandless; slightly shrinking after spore ripeness, but usually not falling off
Sporangia	usually 95–100% normally developed and filled with spores	usually 95–100% normally developed and filled with spores	only 40–50% developed normally; each sorus with many yellowish-whitish sporangia that do not release any spores
Spores	mostly 80–95% normal, well-formed	over 60–90% well-formed, but with a significant proportion of smaller, deformed, dark structures	only 5–10% well-formed spores, the rest (over 90–95%) aborted
mean spore length [1)] in µm	45–56 (see also Bär & Eschelmüller, 1986 as subsp. *robusta*, Jäger & Leonhards 1995, Freigang & Zenner 2007, Bär et al. 2020)	58–63	58–68 (see also Bär & Eschelmüller, 1986, Jäger & Leonhards 1995)
medium stomata cell length [1)] in µm	49–57 (Freigang & Zenner 2007, see also Jäger & Leonhards 1995, Bär et al. 2020)	63–66	58–70 (see also Jäger & Leonhards 1995, Bizot 2014, Bär et al. 2020)
Cytology (and chromosome pairing in meiosis)	triploid, 2n = 123, n = 123 II (8-cell spore mother cell type), n = 10–18 II + 87–103 I (16-cell spore mother cell type, Fraser-Jenkins 2007)	tetraploid, n = approx. 41 II + approx. 82 I (16-cell spore mother cell type)	tetraploid, 2n = 164 (Rasbach in Jessen, 1991 to SJ-1309)
DNA content in pg / 2C	(24.14–) 24.33–25.03 (–26.14) (Ekrt et al. 2009, Bär et al. 2020)	(33.88–) 33.94–34.49 (–34.53) (det. J. Fuchs)	(31.9–) 32.11–33.02 (–34.41) (det. J. Fuchs)

[1)] Mean values from 20–100 measurements

Figure 1: *Dryopteris carpatica*, SJ-136, cult. in the Arctic-Alpine Garden Chemnitz; picture: S. Jeßen 20.05.2013.

Figure 2. Pinnae of the middle area of the leaf blade of: A: *Dryopteris carpatica* (SJ-136), B: *D. carpatica* (SJ-1307/1), C: *D.* × *complexa* nothosubsp. *complexa* (SJ-1309/1); scale bar = 2 cm., pictures: W. Bujnoch.

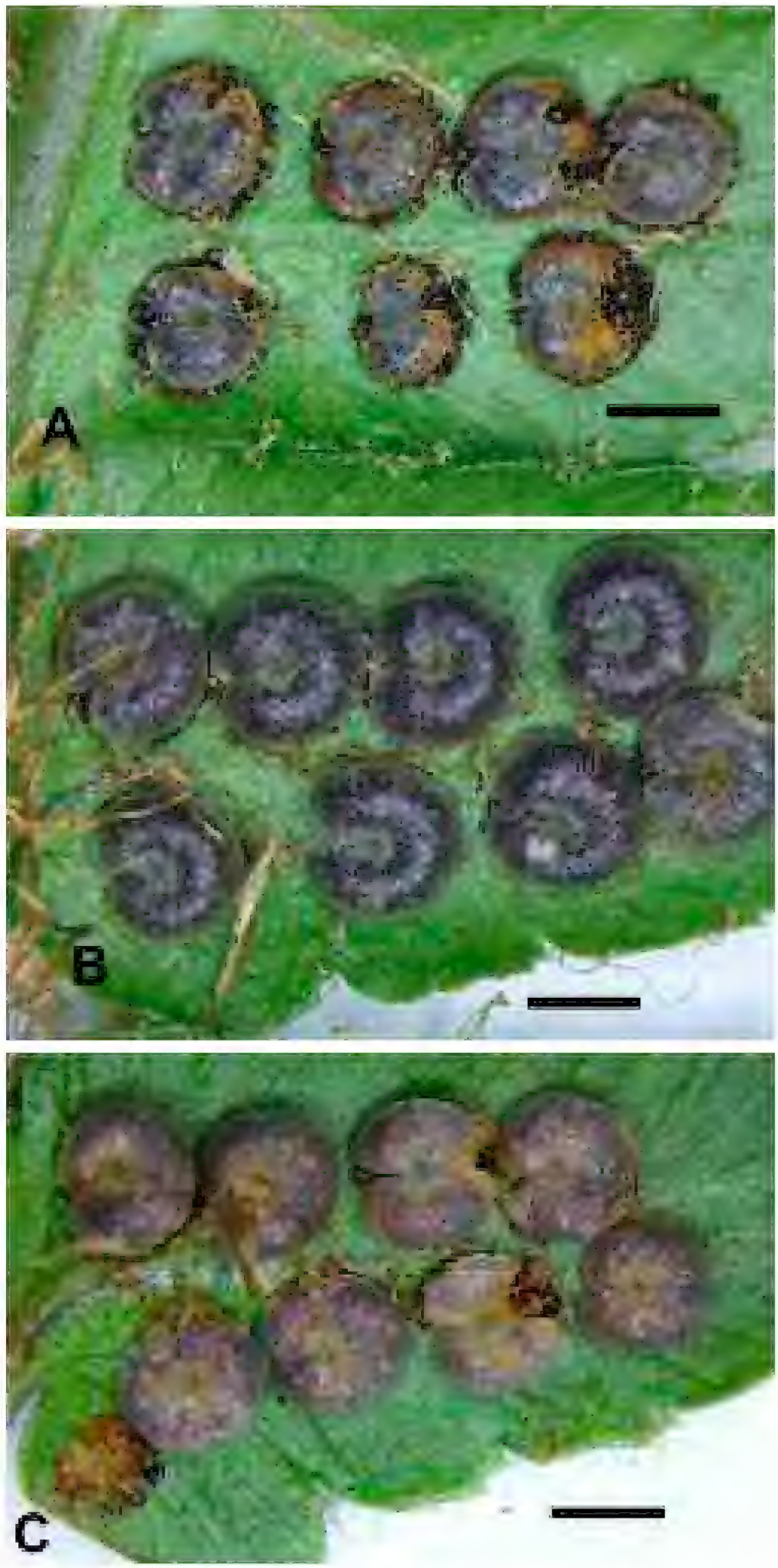

Figure 3. Sori shortly before spore maturity of: A: *Dryopteris carpatica* (SJ-136), B: *D. carpatica* (SJ-1307/1), C: *D.* ×*complexa* nothosubsp. *complexa* (SJ-1309/1); scale bar = 1 cm., pictures: W. Bujnoch; *D. carpatica* shows bulging, blackish sporangia under the indusia, while hybrids such as *D.* ×*complexa* nothosubsp. *complexa* already stand out due to the slightly pink sori, which predominantly contain incorrectly developed sporangia.

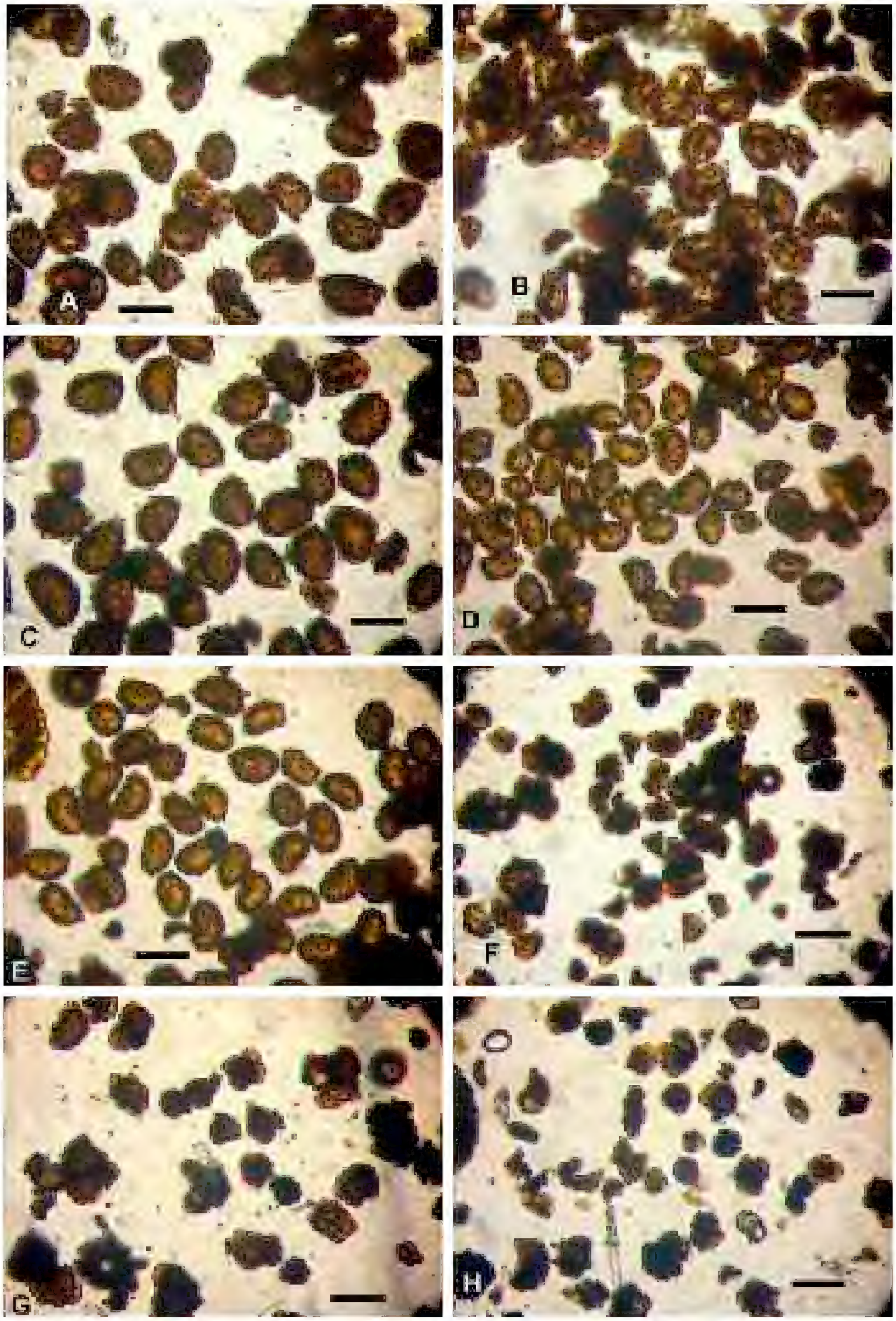

Figure 4. Spore material from: A: *Dryopteris carpatica* (SJ-136), B: *D. carpatica*(SJ-1307/1), C: *D. ardechensis* (SJ-2327/1), D: *D. borreri* (SJ-151), E: *D. lacunosa*(SJ-2953), F: *D.* ×*complexa* nothosubsp. *complexa* (SJ-1309/1), G: *D.* ×*critica*(SJ-1291/1), H: *D.* ×*complexa* nothosubsp. *transsilvanica* (SJ-1310); scale bars = 50 µm., pictures: S. Jeßen.

Table 2. Results of the flow cytometric genome size measurements of various taxa of the *Dryopteris affinis* agg.

Nr.	Taxon	Locality	pg/2C	pg/2C Ø	det.	Ploidy
SJ-3870	*D. affinis* subsp. *affinis* var. *affinis*	Turkey, NE Anatolia	17.48–17.51	17.50	J. Fuchs 16.10.2014	diploid
SJ-3175	*D. affinis* subsp. *affinis* var. *disjuncta*	Germany, Saxony	17.41–17.47	17.44	J. Fuchs 15.10.2014	diploid
SJ-3951	*D. affinis* subsp. *affinis* var. *disjuncta*	Germany, Saxony	17.42–17.49	17.45	J. Fuchs 15.10.2014	diploid
SJ-1305	*D. affinis* subsp. *jessenii*	Romania, Southern Carpathians	17.48–17.58	17.52	J. Fuchs 15.10.2014	diploid
SJ-3942	*D. affinis* subsp. *punctata*	Switzerland, Canton of Zurich	17.46–17.53	17.49	J. Fuchs 15.10.2014	diploid
ML1	*D. borreri*	Germany, North Rhine-Westphalia	24.62–25.01	24.80	J. Fuchs 21.07.2014	triploid
SJ-2166	*D. lacunosa*	Switzerland, Canton Ticino	25.79–25.98	25.88	J. Fuchs 16.10.2014	triploid
SJ-386	*D. pseudodisjuncta*	Germany, Allgäu	25.72–25.91	25.80	J. Fuchs 16.10.2014	triploid
SJ-1028	*D. schorapanensis*	Iran	25.71–25.88	25.79	J. Fuchs 16.10.2014	triploid
SJ-136	*D. carpatica*	Romania, Southern Carpathians	34.46–34.53	34.49	J. Fuchs 10.12.2014	tetraploid
SJ-1307/1	*D. carpatica*	Romania, Southern Carpathians	33.88–34.17	34.02	J. Fuchs 10.12.2014	tetraploid
SJ-1307/2	*D. carpatica*	Romania, Southern Carpathians	33.86–34.22	34.03	J. Fuchs 16.10.2014 u. 10.12.2014	tetraploid
SJ-2818	*D. filix-mas*	Germany, Saxony	31.51–31.93	31.78	J. Fuchs 29.06.2016	tetraploid
SJ-2091	*D.* ×*complexa* nothosubsp. *complexa*	Germany, Allgäu	31.90–32.93	32.50	J. Fuchs 01./08.10.2014	tetraploid
SJ-2135	*D.* ×*complexa* nothosubsp. *eschelmuelleri*	Austria, Vorarlberg	34.11–34.57	34.39	J. Fuchs 15.10.2014	tetraploid
SJ-1303	*D.* ×*complexa* nothosubsp. *transsilvanica*	Romania, Southern Carpathians	31.95–32.22	32.05	J. Fuchs 29.06.2016	tetraploid
SJ-4006	*D. cambrensis subsp. pseudocomplexa*	Scotland	32.00–33.06	32.42	J. Fuchs 29.06.2016	tetraploid

Molecular genetic investigation of a fragment of the nuclear PgiC gene revealed an electropherogram with only one signal at approximately 530 base pairs (bp) for *D. carpatica.* This signal is typical for "*Dryopteris semiaffinis*" as well as for *D. oreades* and *D. caucasica*, while other European species, such as *D. aemula* (Aiton) Kuntze, *D. expansa* (C.Presl) Fraser-Jenk. & Jermy, *D. pallida* (Bory) C.Chr. ex Maire & Petitmengin or *D. villarii* (Bellardi) Woynar ex Schinz & Thell. show other signals (Bujnoch, 2015). Thus, the result provides at least no evidence for the presence of a chromosome set of a species other than "*Dryopteris semiaffinis*", *D. oreades* and *D. caucasica*. In the case of the tetraploid *D. ardechensis,* which also belongs to the *D. affinis* agg. in a broader sense, in addition to the chromosome sets of "*Dryopteris semiaffinis*" and *D. oreades*, another one of *D. pallida* is in play (Fraser-Jenkins & Widén, 1993).

If one gives the abbreviation "Sa" to a chromosome set of the hypothetical "*Dryopteris semiaffinis*", "O" to *D. oreades*, and "C" to *D. caucasica*, the genome formula for *D. affinis* s. str., for example, is "SaO", for *D. borreri* "SaOC", for *D. cambrensis* "SaOO" and for *D. filix-mas* "CCOO". The occurrence of c. 41 bivalents in a "16-celled" meiosis in *D. carpatica* suggests that two of the four chromosome sets are homologous. If it is assumed that in addition to the "*Dryopteris semiaffinis*" *D. oreades* and/or *D. caucasica* are parental taxa, the possible combinations for *D. carpatica* would be "SaOCC", "SaOOC", "SaOOO" or "SaCCC". "SaOOO" should be very similar to *D. oreades* and would be expected to show distinct glands but this is not the case. Similarly *D. carpatica* shows none of the fine-limbed blade and the flat spreading indusia of *D. caucasica*, and so "SaCCC" also seems unlikely. *D. carpatica* is very similar to *D.*

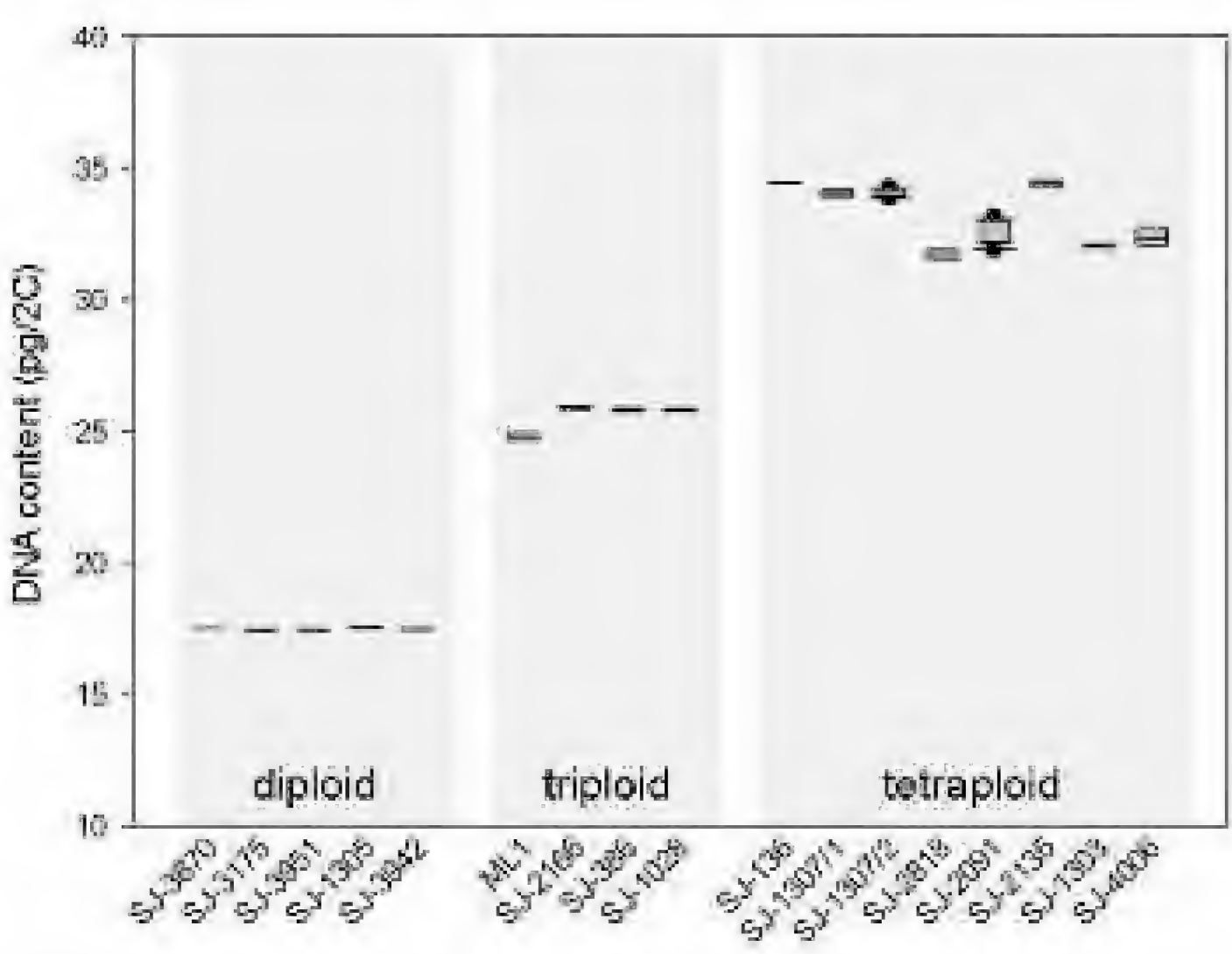

Figure 5. Comparison of the DNA contents of different ploidy levels in the *Dryopteris affinis* agg. Taxon numbers as given in Table 2.

× *complexa* nothosubsp. *complexa* which is represented as "SaOOC" and this formula fits most closely the morphology for *D. carpatica*.

According to Ekrt & Koutecky (2015), hybrids within the genus *Dryopteris* are usually characterized by over 90% aborted spore material. Apomictic species may also show a high proportion of aborted spores, but usually remain well below 30%, except in one case (*D. borreri*) that showed 60% of aborted spores (Ekrt & Koutecky, 2015).

We recognise *D. carpatica* as a distinct taxon as it does not have a high proportion of undeveloped sporangia and aborted spores like the hybrids *D.* × *complexa* nothosubsp. *complexa* or *D.* × *critica*, and does not occur as individual specimens like hybrids, but is able to form large populations in the montane and high montane zones of the Southern Carpathians.

TYPIFICATION AND DESCRIPTION

***Dryopteris carpatica* S. Jess. & Bujnoch spec. nov. (Carpathian Scaly Male Fern)**

Holotypus: SJ-136, leg. S. Jeßen 17.08.1982, cult. in the Arctic-Alpine Garden Chemnitz, 26.06.2016 (JE)

Isotypus: SJ-136, leg. S. Jeßen 17.08.1982, cult. in the Arctic-Alpine Garden Chemnitz, 26.06.2016 (Herbarium S. Jeßen)

Paratypi: SJ-136, leg. S. Jeßen 17.08.1982; SJ-1307; SJ-1308

Locus: Romania, Southern Carpathians, North Făgăraş south of Cârţişoara: fern-rich forest slope on the left slope of the Bâlea valley below the hotel "Bâlea Cascada", approx. 1225 m a.s.l.

Rhizome with one or more heads, fronds arranged in a funnel shape; Leaves similar to *D. filix-mas*, but thicker and with hemispherical indusia before spore maturity and denser scales on the petiole; Blade mostly dull, yellow to dark green, lanceolate to broadly lanceolate, strongly narrowed towards the base, glandless, up to 130 (–150) cm long and up to 30 (–35) cm wide; Petiole 1/5–1/4 of frond length; Scales on the petiole are numerous and relatively dense, up to approx. 20 × 6 mm, light to yellowish-brown, often with a dark to black-brown zone at the base; Scales on the middle rachis and on the

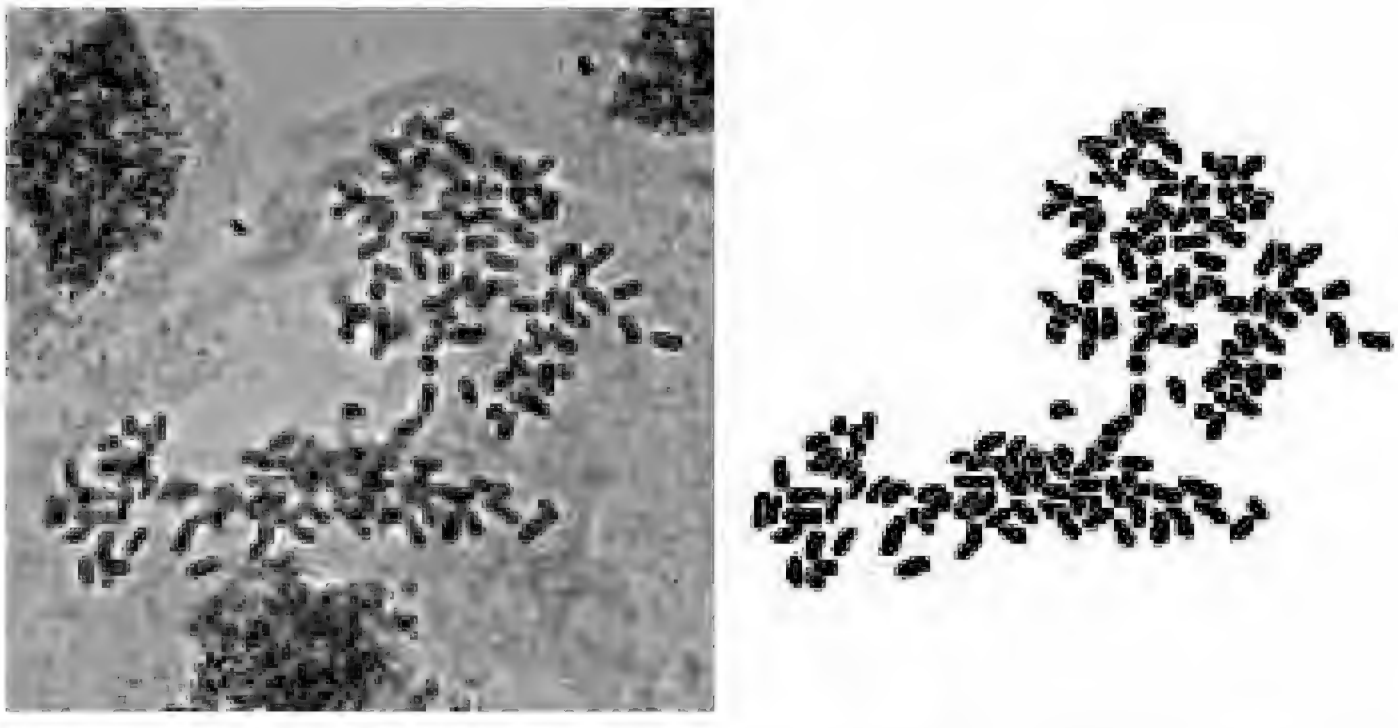

Figure 6. Mitosis in *D. carpatica* (SJ-136) left: preparation FCUW117b, photo: W. Bujnoch; right: explanatory diagram: S. Jeßen. 164 chromosomes can be seen, the plant is tetraploid.

pinnate spindles subpulate, monochrome or with a dark brown base; Lowermost leaflets stalked 1–4 mm long, up to approx. 7 × 2.5 cm; lowest basiscopic pinnate section approx. 1.3–1.5 times longer than the acroscopic section opposite, lobed to the side and provided with short teeth; Middle pinnae 1–3 mm stalked, up to 17 cm long and 3.0–3.5 cm wide, with 20–28 pairs of segments; The base of the pinnate rachis is green or 1–3 mm long, suggestively violet-black; Pinna segments of the middle pinna crowded, only those near the base separated by boot-shaped, otherwise ± V- or U-shaped spaces, 7 × 1.5 mm, 2–2.5 times longer than wide, seated broadly, slightly trapezoidal narrowing upwards or obliquely narrow-rectangular (to almost rhombic), not wavy at the edge, somewhat lobed or toothed, mostly at the end rounded, less often trimmed, with short, forward-facing teeth; The veins on the upper side of the pinnate sections are slightly depressed; Sorus 1.0–1.4 mm in diameter; Indusium domed hemispherically over the immature sorus, rarely with isolated glands, at the spore ripening with a thinner, wavy, sometimes tearing margin, after the spore ripeness shrinking and funnel-shaped, but mostly not sloping; Sporangia are usually 95 to 100% filled with spores; Spore ripening July to August depending on the altitude; 60 to 90% of the spores are well-formed, bean-shaped, but also a noticeable proportion of heterogeneous, deformed structures that vary in size; Stomata cell length 59–66 µm (mean values); Spore length 58–63 µm (mean values); Cytology: n = 2n = 164, tetraploid, apomictic; n = approx. 41 bivalents and approx. 82 univalents; DNA content: (33.88–) 33.94–34.49 (–34.53) pg/2C.

Derivation: Named after the area of discovery, the Carpathian mountain range.

A tetraploid taxon of *Dryopteris affinis* agg. from the western Harz Mountains (Germany, Niedersachsen), comprising a population of 30 individuals and showing predominantly intact spores (Bär et al., 2020) appears to be very similar to *D. carpatica* based on morphology, but its identity awaits confirmation by meiotic and genetic studies.

Fraser-Jenkins (2007) described a new taxon, *D. cambrensis* subsp. *pseudocomplexa*, from the Isle of Skye, Scotland. Already Pigott (1997) mentioned this under

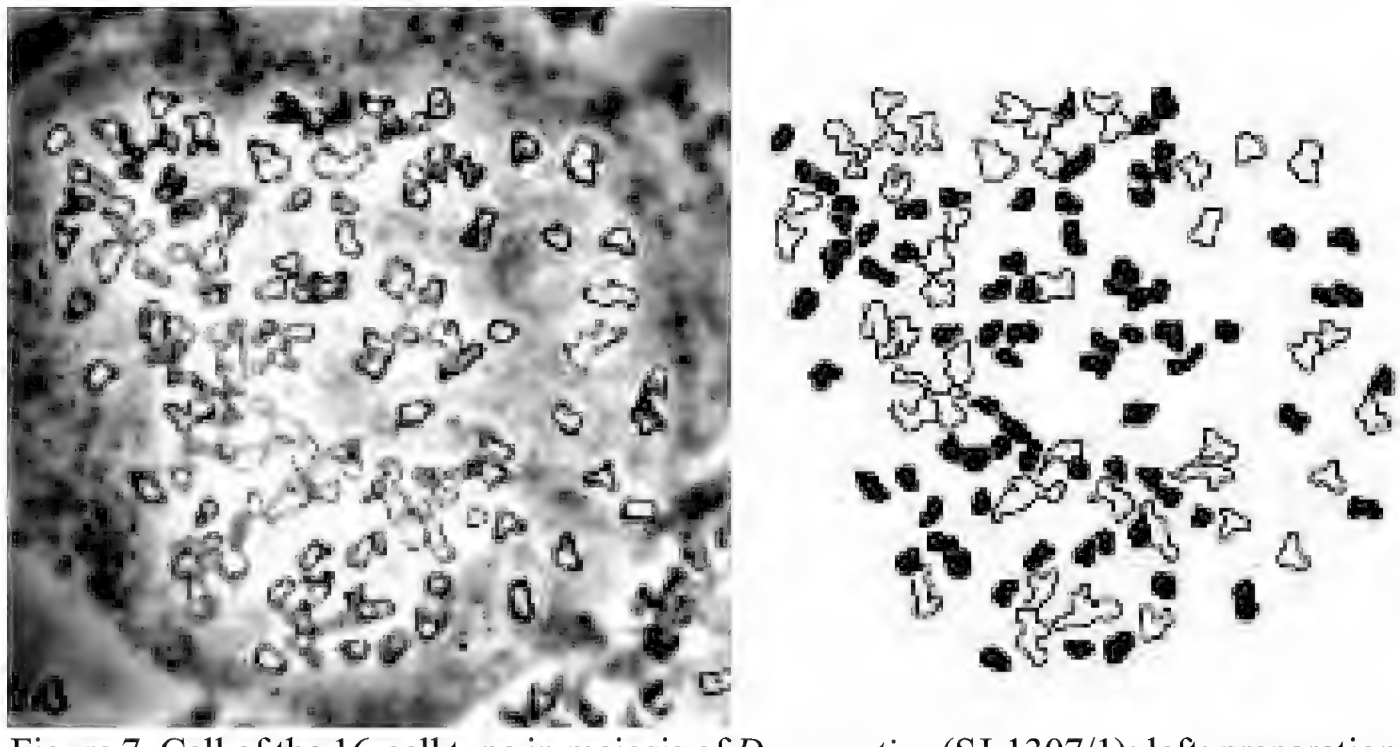

Figure 7. Cell of the 16-cell type in meiosis of *D. carpatica* (SJ-1307/1): left: preparation FCUM159, photo: W. Bujnoch; right: explanatory diagram: S. Jeßen: univalents black, bivalents in outline; 42 bivalents and 80 univalents were determined.

"morphotype Arranensis". Also according to the description and illustrations in Golding (2015), the taxon is morphologically similar to *D.* ×*complexa* nothosubsp. *complexa*. Sell (2018) treats it as a species, *D. pseudocomplexa* (Fraser-Jenk.) P.D. Sell. and states that the spores are large and predominantly good. One plant determined as *D. cambrensis* subsp. *pseudocomplexa* from Arran (SJ-4006) mentioned in Fraser-Jenkins (2007) was found to have a DNA content of 32.42 pg/2C (see Figure 5) which would confirm the taxon as tetraploid. In contrast to *D. carpatica* and the plants of Harz Mts. the plant clearly has glands on the leaves. Analysis of a fragment of the nuclear PgiC gene clearly showed two signals in the electropherogram, one at about 530 base pairs (bp) and one at 519-520 dp (Bujnoch unpublished). This is in contrast to the finding in *D. carpatica* (see above) and suggests that another genome is contained in *D. pseudocomplexa*. Further investigations should clarify whether the plants of the type locality of *D. pseudocomplexa* are tetraploid and whether the taxon corresponds to *D. carpatica* or the taxon from Arran. Note added in proof:

More recently, plants of *D. pseudocomplexa* from the type locality (Isle of Skye) have been confirmed as tetraploid by Bennert et al. (2022) and, based on morphological comparison, these authors also assign tetraploids from the Harz Mts. (Germany) (see Bär et al., 2020) and Vosges Mts. (France) to this taxon.

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AN UNEXPECTED *EQUISETUM* (EQUISETACEAE) TAXON NEW TO THE EUROPEAN FLORA

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Key Words: *Equisetum hyemale* subsp. *affine*, *Equisetum* ×*moorei*, nothosubspecies nova, Germany, Japan

ABSTRACT

A new diploid nothosubspecies of *Equisetum* ×*moorei* is described from a limestone quarry in Germany as the cross between the alien *E. hyemale* subsp. *affine* and *E. ramosissimum*. Its diagnostic features are listed in detail and compared with those of native European *E.* ×*moorei*, the parent taxa of both, and the somewhat similar triploid *E.* ×*geissertii*. Plants close in morphology to the new taxon are found in Japan, where both parent species co-occur naturally. The name of the new nothosubspecies refers to this fact and hence a type specimen from Japan is selected.

INTRODUCTION

The European horsetail flora (*Equisetum*, Equisetaceae) consists of 10 native species distributed over two subgenera (*Equisetum* and *Hippochaete*). Within these subgenera several natural occurring hybrids have been described (see summarizing overview in Prelli & Boudrie, 2021), some fairly common, others extremely rare, and a few ones that are not fully understood in their morphological and genetic delimitation. Those within subgenus *Hippochaete* occur between all known native European species either as primary diploid hybrids or as triploid crosses or backcrosses. In all known diploid or triploid hybrid combinations within *Hippochaete* the nuclear DNA contents measured by means of flow cytometry fit well with the predicted ones based on the measured values of the parental species (Bennert et al., 2005; Christenhusz et al., 2021). The only obvious exception is the recently described *E.* ×*lapponicum* Lubienski & Dörken (*E. scirpoides* × *E. variegatum*; Lubienski & Dörken, 2016) which, according to unpublished data, has a DNA amount similar to that of *E. variegatum* Schleich. ex Weber & Mohr (Bennert & Lubienski, unpubl.).

Additionally one alien species, *Equisetum hyemale* L. subsp. *affine* (Engelm.) Calder & R.L.Taylor, is known to occur as a garden escape in a few European countries (Great Britain, Germany, Belgium, and the Netherlands; Prelli & Boudrie, 2021) and in Brazil (Christenhusz et al., 2019). This taxon naturally occurs in North America and the Pacific coast of North Eastern Asia (Hauke, 1963; 1993), but is widely offered as a garden pond plant and in the cut flower trade often as "*Equisetum japonicum*". Several names for it are known at different taxonomic levels (*robustum*, *japonicum*, *camtchatcense*, *komarovi*, *californicum*, *prealtum*; see Hauke, 1963) and the plant frequently has been listed at species rank, e.g. as *E. praealtum* Raf. by Christenhusz et al. (2019; 2021).

Lubienski et al. (2019) described a disused and difficult to access limestone quarry in Germany, where several different *Equisetum* species (*E. palustre* L., *E. telmateia* Ehrh.,

E. variegatum, *E. hyemale* subsp. *affine*) have established, presumably from spores. The ecological conditions at this site must have enabled sexual hybrid formation between the *Hippochaete* species present (*E. variegatum* or *E. hyemale* subsp. *affine*) and a third one, *E. ramosissimum* Desf., which at the time was not observed at the site. This led to the establishment of a small population of *E.* ×*meridionale* (Milde) Chiov. (*E. ramosissimum* × *E. variegatum*) and a larger one, which at the time was determined as *E.* ×*moorei* s.l. (*E. hyemale* s.l. × *E. ramosissimum*). Because plants of this clone showed distinct differences from *E.* ×*moorei* Newm. and grew in the immediate vicinity to a large stand of *E. hyemale* subsp. *affine*, further investigations have been undertaken and the taxon is now recognized as the hybrid between the non-European subspecies, *E. hyemale* subsp. *affine* and *E. ramosissimum*. Consequently this rather unexpected hybrid combination is described here as a new member of the European flora.

MATERIAL AND METHODS

In order to make extensive comparative investigations between the involved taxa, fresh, cultivated, and dried plant material was used for the present study and is listed in Table 1. In addition, material from several herbaria has been accessed via the Global Biodiversity Information Facility (GBIF, Copenhagen, Denmark) or obtained on loan. Abbreviations for herbaria follow Index Herbariorum (http://sweetgum.nybg.org).

Plant material was measured with regard to various macromorphological criteria (shoot size, shoot diameter and ridge number, branching pattern, characters of the nodal sheath and its teeth) and compared with data found in the literature (especially with Hauke, 1963). Additionally, it was compared with specimens of the herbarium collections of the Osaka Museum of Natural History (Osaka, Japan; OSA) and the National Museum of Nature and Science (Tokyo, Japan; TNS). In order to determine which subspecies of *E. hyemale* occurs in Japan, herbarium specimens from 18 prefectures (from Hokkaido in the North to Ehime in the South) were screened online. Some material from TNS was loaned and studied in detail at the LWL-Museum für Naturkunde (Münster, Germany; MSTR) (Table 1).

Micromorphological data were gathered from several previous publications dealing with SEM techniques on subgenus *Hippochaete* (Bennert & Böcker, 1991; Geiger, 1981; Jepson et al., 2013; Körner, 2003; Lubienski et al., 2010). Spore material was obtained from pressed and air dried fertile shoots by opening the sporangia and embedding the spores in Corbit-Balsam. Slide preparations were dried for 24 hours. Microphotography was made using a digital microscope (Keyence VHX 500F) equipped with a high-precision VH mounting stand with X-Y stage and bright field illumination (Keyence VH-S5).

The absolute 2C DNA content of plants attributed to the hybrid combination *E. hyemale* subsp. *affine* × *E. ramosissimum* from Hagen (Germany) ("*E.* ×*moorei* s.l.") was determined by flow cytometry to estimate ploidy level. Small pieces of freshly collected shoot tissue were chopped with a sharp razor blade together with equivalent amounts of leaf tissue of the reference standard *Vicia faba* 'Tinova' (Gatersleben Genbank accession number: FAB 602; 26.21 pg/2C) using the 'CyStain PI OxProtect' nuclei extraction and staining kit (Sysmex) according to the manufacturer's instruction. The resulting nuclei suspensions were filtered through 50 µm CellTrics filters (Sysmex) and measured on a CyFlow Space flow cytometer (Sysmex). The absolute DNA content was calculated based on the ratios of the G1 peak means of sample and reference standard. Three individual plants were measured twice on two different days.

Table 1: Plant material used in this study (BG = Botanical Garden; MLcult = Living collection M. Lubienski; ML = Herbarium, private M. Lubienski; OSA = Herbarium Osaka Museum of Natural History; PA = Coll. No. Patrick Acock, Great Britain; SJ = Coll. No. Stefan Jeßen, Arktisch-Alpiner Garten Chemnitz, Germany; TNS = Herbarium National Museum of Nature and Science Tokyo; ! = material studied in detail at MSTR).

Taxon	Country, Origin	Collection No.	Cultivation No.	Date of field observation
E. hyemale subsp. *hyemale*	Germany	ML-156	MLcult 201	30.08.2021
		ML-693	MLcult 110	
		ML-694	MLcult 111	
		ML-983		
	Belgium	ML-918		
	France	ML-586		
	Austria	ML-1131		
	Latvia	ML-778	MLcult 151	
	Latvia	ML-783	MLcult 152	
	Finland		MLcult 291	
	Norway	ML-555		
E. hyemale subsp. *affine*	Japan		MLcult 369	
		TNS-923385		
		TNS-949764		
		TNS-965946		
		TNS-984517		
		TNS-496049 !		
		TNS-460824 !		
		TNS-460823 !		
		TNS-460822 !		
		TNS-582040 !		
		TNS-581182 !		
		TNS-572469 !		
		TNS-521996 !		
		TNS-573252 !		
	Germany No. 1	ML-1257	MLcult 338	31.08.2021
		ML-1276	MLcult 351	
			MLcult 361	
		ML-1289	MLcult 362	
	Germany No. 2	ML-1311		24.08.2021
		ML-1312	MLcult 371	
	(BG Chemnitz, *E. robustum*)	SJ-1854	MLcult 360	
	(BG Bochum, *E. robustum*)	ML-161		
	(Trade)		MLcult 247	
	(Trade, *E. japonicum*)	PA-23	MLcult 359	
	(Trade, *E. camtchatcense*)	PA-53	MLcult 358	
	(Trade, *E. camtchatcense*)	PA-84	MLcult 357	

Table 1: continued

Taxon	Country, Origin	Collection No.	Cultivation No.	Date of field observation
E. ramosissimum	Germany	ML-167	MLcult 31	
		ML-338	MLcult 32	
			MLcult 257	
		ML-1046		
	Netherlands	ML-818		
	Spain	ML-829	MLcult 168	
		ML-853		
	Portugal	ML-423		
	France	ML-502	MLcult 35	
		ML-863		
	Slovenia	ML-942		
E. ×moorei (typical)	Germany			22.08.2021
		ML-46	MLcult 51	
		ML-47	MLcult 52	
			MLcult 301	
		ML-1084	MLcult 290	
		ML-813	MLcult 164	
		ML-841	MLcult 172	
		ML-764	MLcult 139	
		ML-819	MLcult 166	
	Austria	ML-1132		
	Belgium		MLcult 262	
	France	ML-581	MLcult 79	
		ML-862	MLcult 177	
		ML-1221		
	Spain	ML-864	MLcult 178	
			MLcult 277	
	Ireland	PA-83	MLcult 355	
	Poland	ML-44	MLcult 49	
	Estonia	ML-785	MLcult 155	
	Russia	ML-1149	MLcult 304	

Table 1: continued

Taxon	Country, Origin	Collection No.	Cultivation No.	Date of field observation
E. ×*moorei* s.l.	Germany No. 1	ML-1258	MLcult 339	
		ML-1275	MLcult 370	31.08.2021
		ML-1313	MLcult 350	
			MLcult 363	
		ML-1309		
	Germany No. 2		MLcult 372	
	Japan	OSA-90433		
		TNS-490713		
		TNS-490714		
		TNS-490715		
		TNS-490716		
		TNS-490718 !		
		TNS-490719 !		
		TNS-491574		
		TNS-491576		
		TNS-493627		
		TNS-493628		
		TNS-1181628		
		TNS-1181629		
		TNS-1183642		
		TNS-1183643		
		TNS-1183644		
Equisetum ×*geissertii*	Germany	ML-577	MLcult 77	
		ML-671		
		ML-684	MLcult 108	
		ML-744		
		ML-791		
		ML-792	MLcult 157	
		ML-798	MLcult 161	
		ML-799	MLcult 162	
		ML-800	MLcult 163	
		ML-842	MLcult 173	
		ML-844		
		ML-879	MLcult 180	
		ML-888	MLcult 183	
		ML-902		
		ML-934	MLcult 208	
		ML-935	MLcult 209	
		ML-939	MLcult 211	
		ML-940	MLcult 212	
		ML-1048		
		ML-1049		
		ML-1082		

RESULTS

DNA CONTENT

The determination of the DNA content of the hybrid plants from Hagen (Germany) by means of flow cytometry resulted in a mean 2C DNA content of 53.98 pg (Table 2). Additionally three provenances of typical European *E.* ×*moorei* were analysed and yielded a mean value of 53.89 pg/2C. These amounts fit well with those published by Bennert et al. (2005) for the same hybrid taxon and lie well within the range of 2C DNA values of diploid species and hybrids of subgenus *Hippochaete* (Bennert et al., 2005; Bainard et al., 2011; Bai et al., 2012; Zhang et al. 2013; Christenhusz et al., 2021). Triploidy therefore can be excluded for the hybrid plants described here, underlining their difference from the morphologically similar triploid *E.* ×*geissertii* Lubienski & Bennert.

COMPARATIVE MORPHOLOGICAL ANALYSIS

Plants of "*E.* ×*moorei* s.l." are in general luxuriant and impressive plants with a very eye-catching toothed appearance characterizing the nodal sheaths: long, dark-brown teeth at the nodal sheaths, with a distinct white membranous margin, and persisting throughout the whole season (Figures 1-4). This feature distinguishes the plants from typical European *E.* ×*moorei*, which loses its teeth early and never shows these white membranous margins around them (Figures 5-7). Additionally, "*E.* ×*moorei* s.l." seems to develop side branches less frequently than the typical hybrid and has slightly thicker shoots; large and thick specimens show less elongated nodal sheaths (Figure 7c). Such large and unbranched plants are quite similar to the parent *E. hyemale* subsp. *affine*, but in contrast have aborted spores in the strobili of their fertile shoots (Figure 8, 9, 11). The hybrid plants from Hagen are in some way reminiscent of *E.* ×*geissertii*, a triploid hybrid taxon endemic to the Upper Rhine valley in Germany which is interpreted by Lubienski et al. (2010) as a triple hybrid, incorporating the genomes of *E. hyemale*, *E. ramosissimum*, and *E. variegatum*. However, our plant is diploid, is taller than *E.* ×*geissertii*, has a larger shoot diameter with on average more ridges (and teeth) on the shoot surface, and has a slightly smaller black girdle at the base of the nodal sheaths (Figures 7, 10).

DISTRIBUTION

Specimens of *E. hyemale* subsp. *affine* × *E. ramosissimum* occur in the prefectures Ishikawa, Gifu, and Aichi, all situated within Chubu region, in the centre of Honshu. A random check of the TNS collection of *E. hyemale* subsp. *affine* revealed several hybrid specimens that had been mistaken for *E. hyemale* subsp. *affine* , including material from Miyagi Prefecture in the Tohoku region, which borders Chubu to the north.

"*Equisetum* ×*moorei* s.l." is known from a single locality in Germany, the disused limestone quarry in Hagen (North Rhine-Westphalia) reported by Lubienski et al. (2019). There was possibly a second site in a sandpit near Wesendorf (Lower Saxony, Germany), but unfortunately the small hybrid population was lost soon after its detection, so that no detailed examination could be carried out. Luckily a small amount of living plant material was saved and is now in cultivation awaiting further study.

Table 2: DNA content of *Equisetum* ×*moorei* s.l. from Hagen (Germany) and related taxa determined by flow cytometry and compared with 2C values published in literature for *Equisetum* subgenus *Hippochaete*.

Taxon	Cultivation No. (ML cult)	Date	Analysis No.	2C-DNA amount [pg]	2C-DNA amount [pg]mean, sample	2C-DNA amount [pg]mean, total
E. ×*moorei* s.l. (Hagen, Germany)	339	28.01.2022	1	53.86	54.01	53.98
	339	02.02.2022	2	54.16		
	370	28.01.2022	1	53.19	53.73	
	370	02.02.2022	2	54.26		
	363	28.01.2022	1	53.91	54.20	
	363	02.02.2022	2	54.50		
E. ×*moorei* (typical)	166	26.01.2022	1	54.32		53.89
	178	27.01.2022	1	53.48		
	178	27.01.2022	2	53.93		
	355	28.01.2022	1	54.25		
E. ×*geissertii*	77	31.01.2022	1	84.37		83.93
	183	31.01.2022	1	82.69		
	212	31.01.2022	1	84.72		
E. ×*moorei* (typical)	Bennert et al., 2005					54.00
E. ×*geissertii*	Bennert et al., 2005					83.80
Range of diploid taxa	Obermayer et al., 2002; Bennert et al., 2005; Bainard et al., 2011;Bai et al., 2012; Zhang et al. 2013; Christenhusz et al., 2021					42.2 – 65.1
Range of triploid taxa	Bennert et al., 2005					78.7 – 84.0

TYPIFICATION AND DESCRIPTION

Equisetum* ×*moorei Newm. nothosubsp. ***nipponicum*** Lubienski, **nothosubsp. nov.** (*Equisetum hyemale* L. subsp. *affine* (Engelm.) Calder & R.L.Taylor × *E. ramosissimum* Desf.)

Holotypus: Japan. Chubu region. Ishikawa prefecture, Ishikawa-gun: Shiramine-mura, 19 Jul 1987, T. Kawahara (TNS-490719). Figure 11, 12.

Isotypus: Japan. Chubu region. Ishikawa prefecture, Ishikawa-gun: Shiramine-mura, 19 Jul 1987, T. Kawahara (TNS-490718).

Paratypus: Germany. North Rhine-Westphalia: Hagen-Hohenlimburg, disused limestone quarry east of Elsey, MTB 4611/144, c. 160 m a. s. l., 09 Jul 2019, Herbarium Marcus Lubienski No. 1309 (MSTR-438455), Figure 13.

Derivation: Named after Nippon, the reading of the Japanese spelling 日本 for Japan, where the hybrid occurs naturally.

DESCRIPTION

Figure 1: *Equisetum* ×*moorei* nothosubsp. *nipponicum*, upper part of fertile shoot with strobilus.

Figure 2: *Equisetum* ×*moorei* nothosubsp. *nipponicum*, young, emerging shoots.

Figure 3: *Equisetum* ×*moorei* nothosubsp. *nipponicum*, basal nodal sheaths in late summer with teeth still present.

Figure 4: *Equisetum* ×*moorei* nothosubsp. *nipponicum*, middle nodal sheaths in late summer with teeth still present.

Figure 5: *Equisetum* ×*moorei* nothosubsp. *nipponicum*, branched nodal sheath with persistent and white membranous teeth.

Figure 6: *Equisetum* ×*moorei* nothosubsp. *moorei*, branched nodal sheath with teeth fallen off.

Plants tall, in size and growth habit intermediate between *E. hyemale* subsp. *affine* and *E. ramosissimum*; shoots evergreen, height 85-120 cm, diameter 5 mm, mostly unbranched, sometimes irregularly branched (upper part of the shoot occasionally dying back in winter), regularly with distinct silica cross bands; nodal sheaths longer than wide, becoming as long as wide in bigger shoots, light grey, upper margin with a distinct black

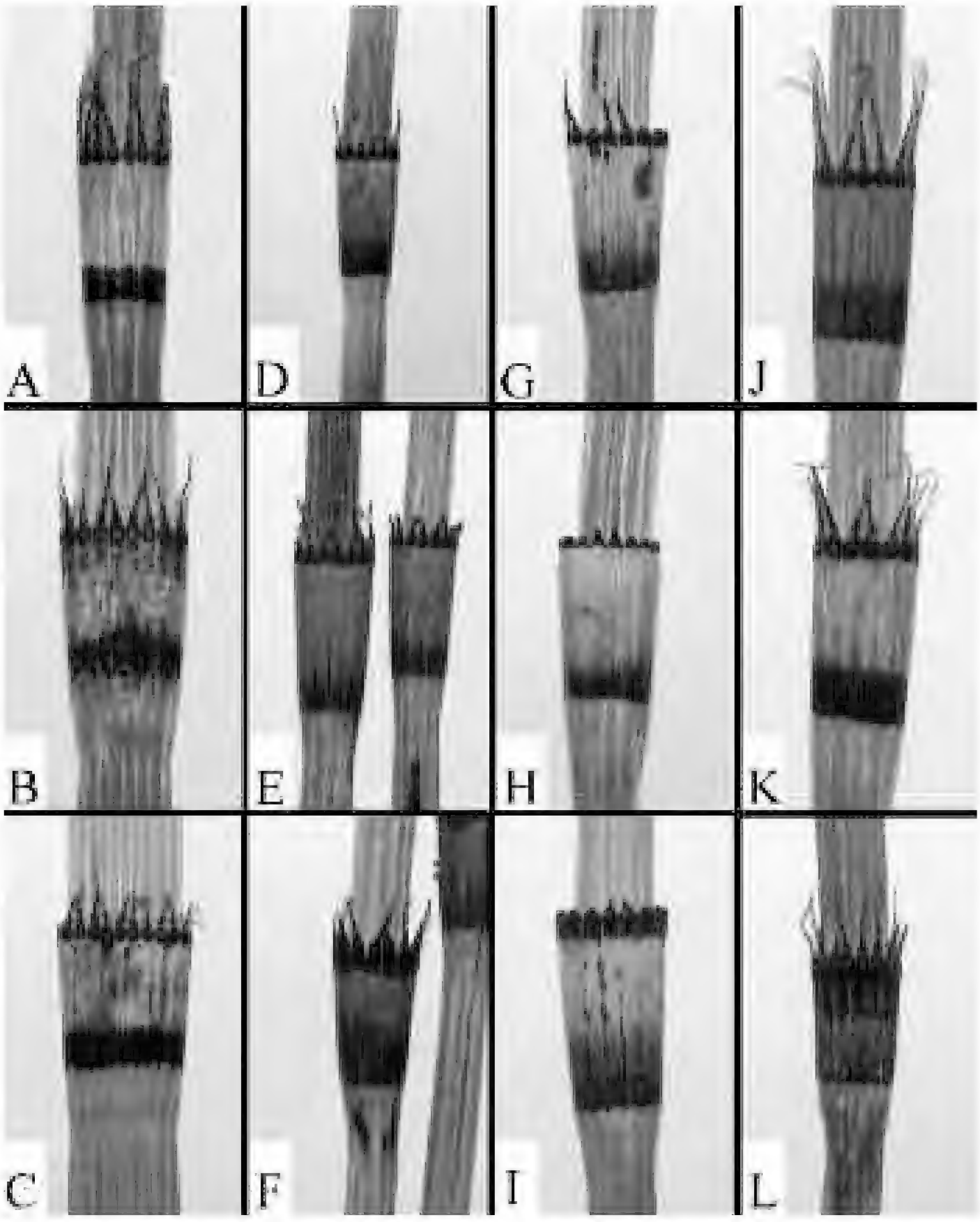

Figure 7: Nodal sheaths of herbarium specimens in comparison: *Equisetum* ×*moorei* nothosubsp. *nipponicum*, Germany (a-c); *Equisetum* ×*moorei* nothosubsp. *nipponicum*, Japan (d-f); *Equisetum* ×*moorei* nothosubsp. *moorei*, Austria/France (g-i); *Equisetum* ×*geissertii*, Germany (j-l).

Figure 8: Well formed spores of *E. ramosissimum*; green-chlorophyllous, spherical, elater-bearing.

Figure 9: Aborted spores of *Equisetum* ×*moorei* nothosubsp. *nipponicum*, non-chlorophyllous, irregularly shaped, without elaters.

Figure 10: Young emerging shoots in comparison: *Equisetum* ×*moorei* nothosubsp. *nipponicum* (left), *Equisetum* ×*moorei* nothosubsp. *moorei* (centre), *Equisetum* ×*geissertii* (right).

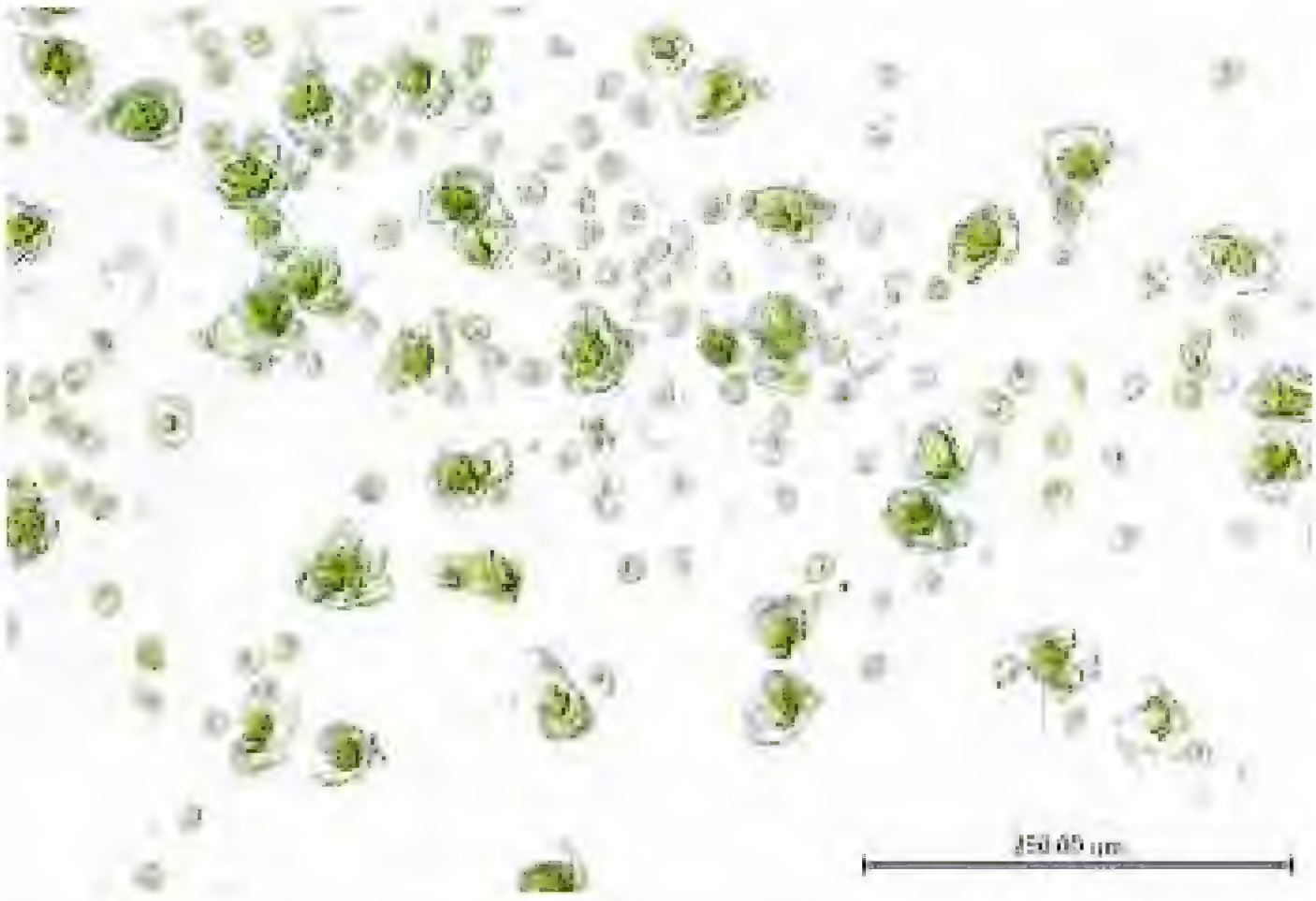

Figure 11: Aborted spores from the holotype specimen of *Equisetum* ×*moorei* nothosubsp. *nipponicum*, non-chlorophyllous, irregularly shaped, without elaters.

Figure 12: Holotype sheet of *Equisetum* ×*moorei* nothosubsp. *nipponicum*: Japan. Chubu region. Ishikawa prefecture, Ishikawa-gun: Shiramine-mura, 19 Jul 1987, T. Kawahara (TNS-490719) (Ebihara, 2021).

Figure 13: Paratype sheet of *Equisetum* ×*moorei* nothosubsp. *nipponicum*: Germany. North Rhine-Westphalia: Hagen-Hohenlimburg, disused limestone quarry east of Elsey, MTB 4611/144, c. 160 m a. s. l., 09 Jul 2019, M. Lubienski (ML-1309; MSTR-438455).

rim, black girdle from the basal ⅕ up to ¼ of the sheath length; teeth of the nodal sheaths approx. 18, persistent throughout, their base still present in the 2nd year, long, dark brown, with a broad white membranous margin; strobili with 10 – 12 whorls of sporophylls, sporangia not opening, spores whitish, achlorophyllous, irregular formed, lacking elaters; 2C-DNA amount c. 54 pg, plants diploid.

DISCUSSION

The macro- and micromorphological characters of *E.* ×*moorei* nothosubsp. *nipponicum*, its parental taxa, and similar taxa are shown in Table 3. Although the comparison of our living plant material from Germany with that from the Japanese herbarium collections results in a fairly consistent morphological concept of a hybrid taxon, which we describe here, one would expect *E.* ×*moorei* nothosubsp. *nipponicum* to be a variable taxon, depending on the form of *E. hyemale* subsp. *affine* involved. Such variability has been observed when comparing the Japanese hybrid plants and those from Germany. As already stated by Hauke (1963), ridge adornment and teeth retention vary geographically in this subspecies, even within its native North American range. Variation is already reported for both North American hybrids derived from *E. hyemale* subsp. *affine* : *E.* ×*ferrissii* Clute (*E. hyemale* subsp. *affine* × *E. laevigatum* A.Braun) and *E.* ×*trachyodon* (A.Braun) W.D.J.Koch (*E. hyemale* subsp. *affine* × *E. variegatum*) (Hauke, 1963).

Equisetum ×*moorei* nothosubsp. *nipponicum* differs in its teeth retention character from European *E.* ×*moorei* nothosubsp. *moorei*, and this characteristic feature likewise separates *E. hyemale* subsp. *affine* (at least in some parts of its North American and East Asian range) from *E. hyemale* subsp. *hyemale*. Similar differences in morphology exist between European and North American *E.* ×*trachyodon* (Hauke, 1963), and they are listed as two different nothosubspecies by some authors (Bizot & Pétrement, 2009; Prélli & Boudrie, 2021). We adopt this concept here for *E.* ×*moorei* (Figure 14).

Although the native ranges of the parent species of *E.* ×*moorei* nothosubsp. *nipponicum* are extensive, both grow together naturally only in Japan and possibly in China and Korea. *Equisetum hyemale* subsp. *affine* is found throughout the North American continent (Alaska, Canada, USA), in parts of Central America (Mexico, Guatemala), the Aleutian Islands, Kamchatka, Sakhalin, Japan and possibly some parts of China (Hauke, 1963; 1993; Christenhusz et al., 2019). Two sheets from the Chinese provinces Hubei (central East China; [NY-03864350]) and Jilin (North East China, bordering North Korea; [MICH-1587646]) clearly belong to that subspecies. Park et al. (2003) state that *E. hyemale* in Korea is probably subsp. *hyemale*, but at the same time express some doubts about this, indicating that further studies are needed. However, two sheets from North and South Korea (MICH-1587636 and F-1598993) show teeth retention features characteristic for *E. hyemale* subsp. *affine*.

According to Christenhusz et al. (2019) *E. hyemale* subsp. *affine* is found exclusively on Hokkaido in Japan, while Honshu and the other Japanese islands harbour only *E. hyemale* subsp. *hyemale*. However, this does not match the data in the detailed and comprehensive monographic work presented by Hauke (1963) and is not confirmed by our herbarium studies in OSA and TNS, which suggest that *E. hyemale* subsp. *affine* is in fact the only subspecies represented in Japan. *Equisetum hyemale* subsp. *affine* is naturalized in Europe (Great Britain, Germany, Belgium, and the Netherlands; Prelli & Boudrie, 2021) and in South America (Brazil; Christenhusz et al., 2019). Because it is widely offered in cultivation, it might be naturalized elsewhere. The other parent species, *E. ramosissimum*, is native from Europe to Pacific Asia and in Africa (Hauke, 1963;

Christenhusz et al., 2019). In Japan it occurs in nearly every prefecture, with the possible exception of the Northern island Hokkaido. It is not known from Kamchatka and Sakhalin, but present in Korea (Park et al., 2003) and naturalized in North America (Hauke, 1979; 1993). Typical *E. ramosissimum* is replaced in South East Asia by a similar taxon (*E. debile* Roxb. ex Vaucher; *E. ramosissimum* Desf. subsp. *debile* (Roxb. ex Vaucher) Hauke; *E. ramosissimum* Desf. var. *huegelii* (Milde) Christenh. & Husby).

Although there are may be some question about which subspecies of *E. hyemale* is native to continental China and adjacent Korea, it is clear that the native ranges of both parents of *E.* ×*moorei* nothosubsp. *nipponicum* overlap in Japan, and this is reflected in the name of the new taxon . Its non-native occurrence in Germany points to the fact that it might exist in other European countries as well, where *E.* ×*moorei* nothosubsp. *nipponicum* could form wherever *E. hyemale* subsp. *affine* is planted or and naturalized within the native range of *E. ramosissimum*. Similarly, it could occur in some parts of North America, where *E. ramosissimum* is naturalized (Figure 14).

A similar question relates to *E.* ×*trachyodon*; Japanese material of this hybrid may be nothosubspecies *jesupii* (A.A.Eaton) Bizot & Pétrement the same subspecies as in North America and hence different from European representatives (Figure 14). Nevertheless this assumption has to be proved in future studies.

With the description of *E.* ×*moorei* nothosubsp. *nipponicum* the number of *Equisetum* taxa (species, subspecies, hybrids) known to be part of the European flora is now raised to 29 (Table 4).

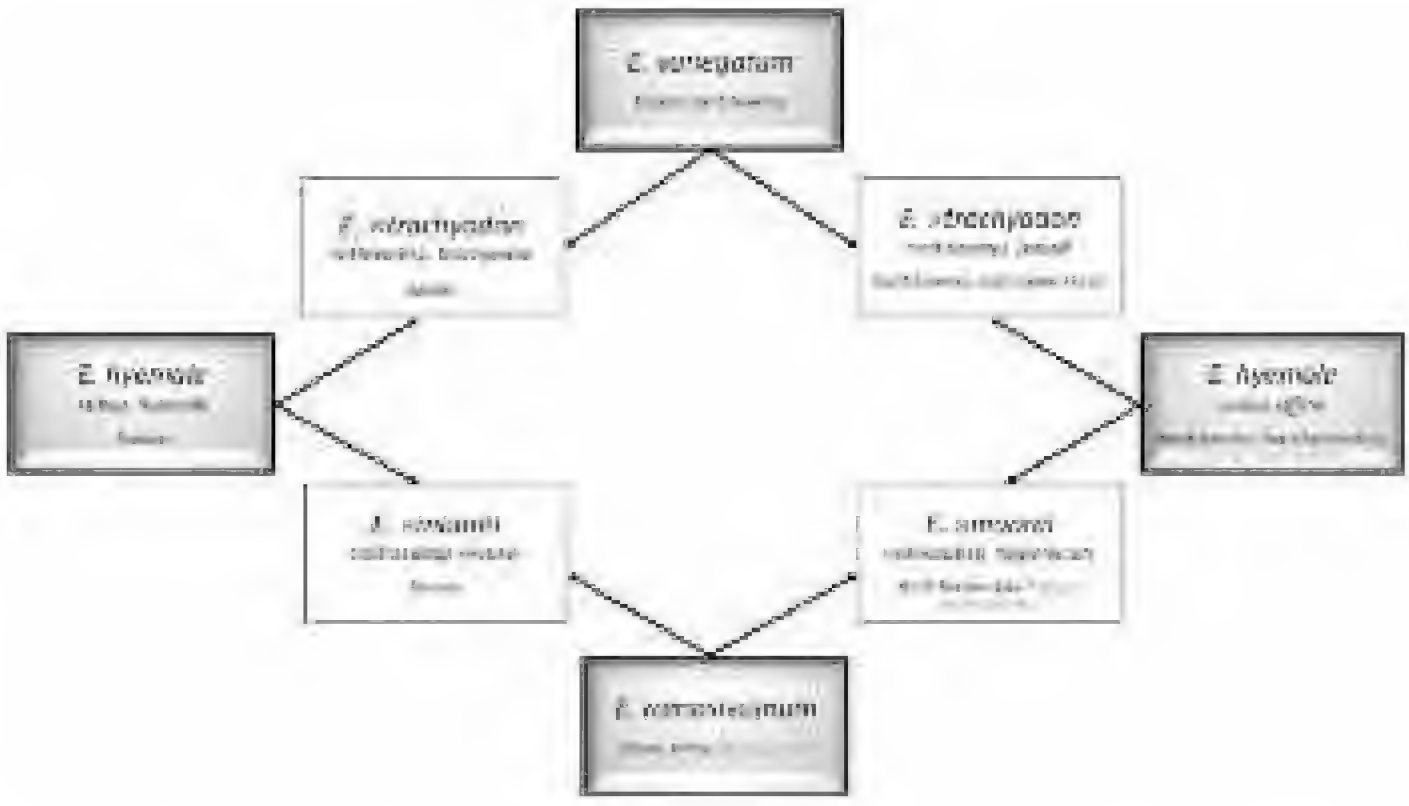

Figure 14: Worldwide hybridization scheme showing different nothotaxa of hybrids involving *Equisetum hyemale*.

Table 3: Macro- and micromorphological characters of *Equisetum* ×*moorei* nothosubsp. *nipponicum*, its parental and similar taxa (gray shaded cells indicate a diagnostically +/- significant difference from *E.* ×*moorei* nothosubsp. *moorei* and / or *E.* ×*geissertii*).

	E. hyemale subsp. *hyemale*	*E.* ×*moorei* nothosubsp. *moorei*	*E. ramosissimum*	*E.* ×*moorei* nothosubsp. *nipponicum*	*E. hyemale* subsp. *affine*	*E.* ×*geissertii*
Ploidy level Genome formula	diploid HH	diploid HR	diploid RR	diploid H'R	diploid H'H'	triploid HRV
Size [cm]	(20-) 35-70 (-100)	(30-) 85-120 (-170)	(30-) 45-120 (-250)	(40-) 85-120 (-170)	(20-) 45-110 (-230)	(40-) 70-90 (-153)
Branching pattern	shoots unbranched, rarely branched when injured at the apex	shoots mostly irregularly branched, sometimes without branches	shoots regularly with whorled branches, sometimes small unbranched shoots	shoots mostly unbranched, sometimes irregularly branched	shoots unbranched, rarely branched when injured at the apex	shoots mostly unbranched, sometimes irregularly branched
Nodal sheath (length-width-ratio) middle to lower third of the shoot	as long as wide, rarely longer than wide	longer than wide	distinctly longer than wide (up to twofold)	longer than wide, becoming as long as wide in larger shoots	as long as wide	longer than wide, rarely as long as wide
Nodal sheath (colour) middle to lower third of the shoot	light grey upper margin with a distinct black rim black girdle at the basal ⅓ to ½ of the sheath length	light grey upper margin with a distinct black rim black girdle at the basal ¼ to ⅓ of the sheath length	sheaths mostly green throughout (young shoots) or totally light grey (mature shoots) with a small black girdle at the base	light grey upper margin with a distinct black rim black girdle at the base to ¼ of the sheath length	light grey upper margin with a distinct black rim black girdle at the bottom ⅓ to ½ of the sheath length	light grey upper margin with a distinct black rim black girdle at the bottom ⅓ to ½ of the sheath length
Nodal sheath (teeth)middle to lower third of the shoot	mostly lost from the sheaths during initial expansion, forming a typical pagoda-like cap on the shoot apexlong, dark brown, without a white membranous margin	always present at the uppermost sheaths of young shoots, but falling off earlylong, dark brown, without a white membranous margin	persistent throughoutvariable; light coloured, often as a colourless and undulate awn on a very short black-deltoid base, sometimes even a fine black centre with a very broad white membranous margin	persistent throughout, their base still present in the 2nd year long, dark brown, with a broad white membranous margin	**(varying across the range)** mostly persistent throughout, partly falling off long, dark brown, with a small white membranous margin, sometimes without	persistent throughout, their base still present in the 2nd yearlong, dark brown, with a broad white membranous margin

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Table 3: continued

	E. hyemale subsp. *hyemale*	*E.* ×*moorei* nothosubsp. *moorei*	*E. ramosissimum*	*E.* ×*moorei* nothosubsp. *nipponicum*	*E. hyemale* subsp. *affine*	*E.* ×*geissertii*
Nodal sheath (number of teeth at the third nodium)[i.e. ridge number]	14- (19) -22	14- (17) -19	11- (15) -17	13- (18) -24	23- (29) -35	8- (11) -16
Shoot (diameter between the third and fourth internodium) [mm]	4- (5) -6.5	3- (4) -5.5	3- (4) -5	3- (5) -8	5- (7.5) -10	2.5- (3.5) -5
Shoot ridge (micro-morphology)	without silica cross bands and a distinct double row of tubercles	regularly with distinct silica cross bands	regularly with distinct silica cross bands	regularly with distinct silica cross bands	**(varying across the range)**with distinct silica cross bands or with an indistinct double row of tubercles	with distinct or obscure silica cross bands
Spores	green-chlorophyllous, spherical, elater-bearing	non-chlorophyllous, irregularly shaped, without elaters	green-chlorophyllous, spherical, elater-bearing	non-chlorophyllous, irregularly shaped, without elaters	green-chlorophyllous, spherical, elater-bearing	non-chlorophyllous, irregularly shaped, without elaters

Table 4: Species and hybrids within *Equisetum* in Europe. Alien taxa printed in grey.

Subgenus *Equisetum*	1 *E. arvense* L. 2 *E. palustre* L. 3 *E. fluviatile* L. 4 *E. telmateia* Ehrh. 5 *E. sylvaticum* L. 6 *E. pratense* Ehrh.	1 × 2 *E.* ×*rothmaleri* C.N.Page 1 × 3 *E.* ×*litorale* Kühlew. ex Rupr. 1 × 4 *E.* ×*robertsii* T.D.Dines 1 × 5 *E.* ×*lofotense* Lubienski 2 × 3 *E.* ×*dycei* C.N.Page 2 × 4 *E.* ×*font-queri* Rothm. 3 × 4 *E.* ×*willmotii* C.N.Page 3 × 6 *E.* ×*mchaffieae* C.N.Page 4 × 5 *E.* ×*bowmanii* C.N.Page 5 × 6 *E.* ×*mildeanum* Rothm.
Subgenus *Hippochaete*	1 *E. hyemale* L. subsp. *hyemale* 2 *E. hyemale* L. subsp. *affine* (Engelm.) Calder & R.L.Taylor 3 *E. ramosissimum* Desf. 4 *E. variegatum* Schleich. ex Web. & Mohr 5 *E. scirpoides* Michx.	1 × 3 *E.* ×*moorei* Newm. nothosubsp. *moorei* 2 × 3 *E.* ×*moorei* Newm. nothosubsp. *nipponicum* Lubienski 1 × 4 *E.* ×*trachyodon* (A.Braun) W.D.J.Koch 3 × 4 *E.* ×*meridionale* (Milde) Chiov. 4 × 5 *E.* ×*lapponicum* Lubienski & Dörken (1×4) × 1 *E.* ×*alsaticum* (H.P.Fuchs & Geissert) G.Philippi in Lubienski & Bennert (1×3) × 1 *E.* ×*ascendens* Lubienski & Bennert 1 × 3 × 4 *E.* ×*geissertii* Lubienski & Bennert

the microscopic images. Nomenclatural questions were answered quickly and comprehensively by Werner Greuter (Berlin, Germany). M.L. would like to express his deep gratitude to his wife Regina Lubienski (Hagen, Germany) for her great support with field work and the metric analyses of plant material.

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CYTOLOGY OF THE RARE AND THREATENED SICKLE FERN *PELLAEA FALCATA* (PTERIDACEAE: PTERIDOPHYTA) FROM INDIA

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Key words: *Pellaea falcata,* Threatened fern, cytology, conservation.

ABSTRACT

There are five species of *Pellaea* in India, of which three are critically endangered. The cytology of only two are known; the cytology of *P. falcata* is known only from Australia as a diploid sexual taxon. *Pellaea falcata* has been collected from Meghamalai (Western Ghats, India), a new distributional area in India, and the present cytological study shows that it is tetraploid and sexual (n=58, 2n =116), with 64 normal spores per sporangium. This is the first chromosome count for *P. falcata* from Asia and is a new cytotype for this species.

INTRODUCTION

The genus *Pellaea* (Pteridaceae: Pteridophyta) comprises about 40 species worldwide and is currently included in the subfamily Cheilanthoideae within Pteridaceae (Windham et al., 2009; PPG 1, 2016). Among the fifteen species in North America there are a number of polyploid and several apogamous species (http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=124283). In contrast, China (http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=124283) has only two species including *P. connectens* C.Chr., a tetraploid sexual endemic (Zhao et al., 2016). In India there are four species (Fraser-Jenkins et al., 2017) *P. boivinii* Hook. *P. calomelanos* (Sw.) Link, *P. falcata* (R.Br.) Fée and P. *longipilosa* Bonap. with a valid cytological report (Bir & Verma, 2010) only for *P. boivinii* n=30, 2n=60. *Pellaea falcata* from Australia is diploid and sexual (Brownsey et al., 2020). *Pellaea falcata, P. calomelanos* and *P. longipilosa* are critically endangered in India (Chandra et al., 2008).

The sickle fern *P. falcata* has a limited distribution (Fraser–Jenkins et al., 2017; Brownsey et al., 2020) in India, Malaysia, Sri Lanka, Australia, New Caledonia and Lord Howe Island; in India it is confined to only two southern states, Tamil Nadu and Kerala, with occasional distribution in Palni Hills, Tirunelveli Hills and Kolli Hills (Manickam & Irudayaraj, 1992; Fraser-Jenkins et al., 2017). It is near threatened in Asia (Fraser-Jenkins, 2012) and India (Chandra et al., 2008). Reports of *P. falcata* from New Zealand (Fraser-Jenkins et al., 2017; Schönberger et al., 2019), have now been re-determined (Brownsey et al., 2020) as *P. rotundifolia* (G.Forst.) Hook. In the present study, *P. falcata* has been discovered from Highwavys Mountain, Meghamalai, Western Ghats, India and has also been determined cytologically.

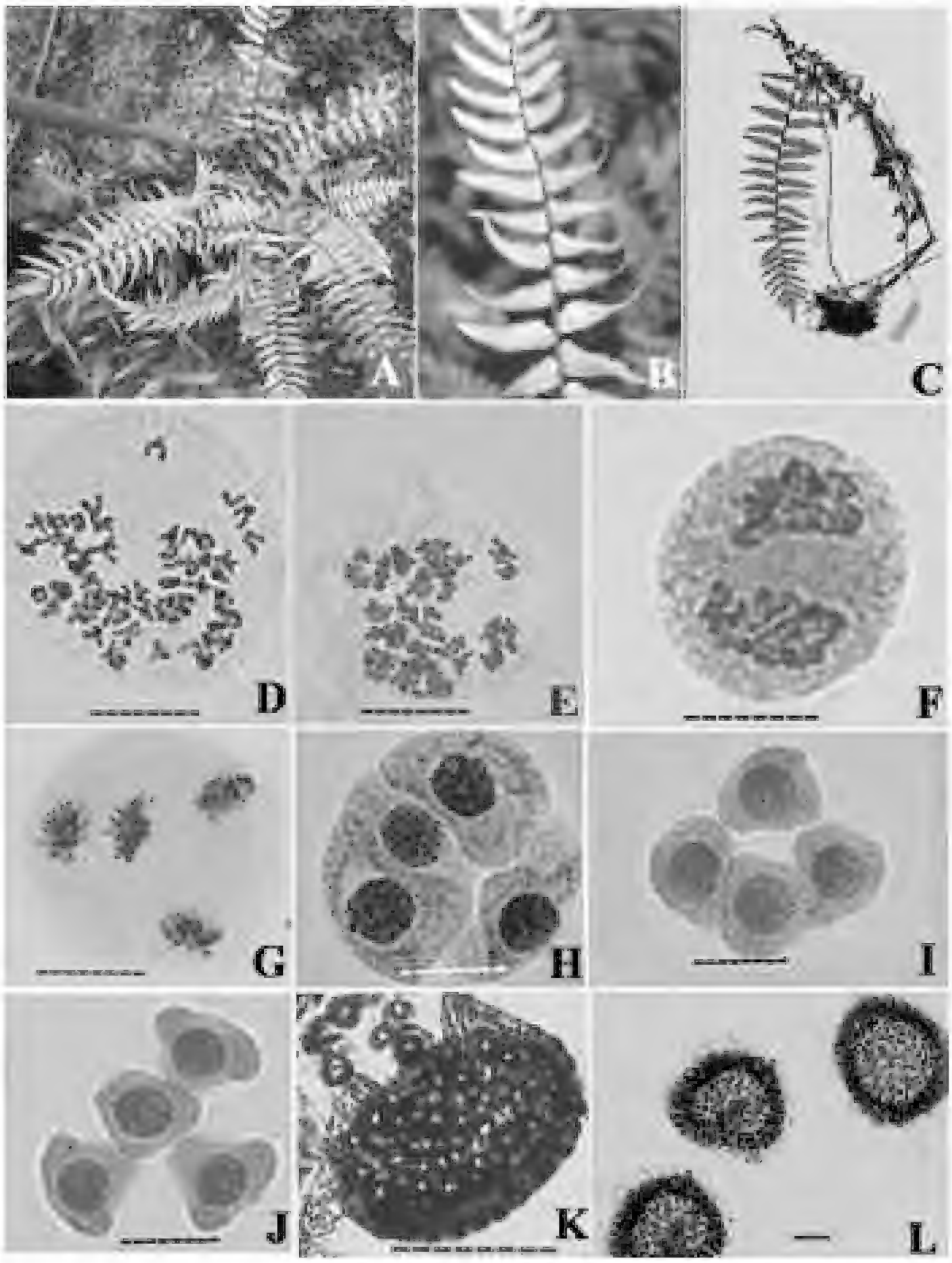

Figure 1. Ecology, morphology and cytology of *Pellaea falcata* A: plant in Kodaikanal Botanical Garden, B: sporophylls, C: habit with long creeping rhizome, D-E: spore mother cell with 58 regular bivalents with explanatory diagram (E), F-G: spore mother cells with first and second telophase respectively, showing regular separation of chromosomes, H-J: normal, uniform daughter cells after second meiosis, K: sporangium with 64 normal spores, L: echinate mature spores (scale bars in Figures D-J, L = 10μm, Figure K = 100 μm).

MATERIALS AND METHODS

Material for cytological studies was collected from Highwavys Mountain, Meghamalai (Theni District, Tamil Nadu), and Western Ghats, India. Croziers of 1-3 cm length (Figure 1P) and young sporophylls were directly placed in the fixative (ethyl alcohol: chloroform: acetic acid in 6:3:1 ratio) without any pretreatment. For observation of mitotic and meiotic chromosomes, the simple acetocarmine-squash technique was followed (Manton, 1950). Vouchers have been deposited in St. Xavier's College Herbarium (XCH), Palayamkottai, India.

RESULTS AND DISCUSSION

Field survey in Highwavys Mountain, Meghamalai, Western Ghats revealed two populations of *P. falcata*, from Central Camp and Vellimalai. Cytological study was carried out on the population (XCH 26562) from Central Camp. Meghamalai, the short eastward offshoot below Palni Hills on the Western Ghats, is the new distributional record for this fern. Nine gatherings were collected from partially exposed stream banks at two different localities (Central Camp – XCH 26509, 26552, 26562, 26610, 26649, 26824, 26849, 26943 and Vellimalai - XCH 26878). Observation of herbarium specimens in XCH confirmed the presence of further gatherings (RHT 31264, 34044, XCH 2356, 2392, 2465) from Tirunelveli Hills, Tamil Nadu, the southernmost part of the Western Ghats (Manickam and Irudayaraj 1992), as well as four gatherings from Periyar Tiger Reserve – Western Ghats, Kerala (Rajesh 2001), two gatherings from Srivilliputhur Hills, Tamil Nadu (XCH 2956, 2985) and one gathering each from Palni Hills, Tamil Nadu (RHT 31137) and Kolli Hills – Eastern Ghats, Tamil Nadu (RHT 33231); the numbers of populations decrease from South to North in the Western Ghats. All the populations are present on the eastern side of the Western Ghats with extension to the Eastern Ghats in South India. They are terrestrial from shaded stream banks, and have long creeping rhizomes, simply pinnate laminae and continuous marginal sori (Figure 1A-C). The chromosome behaviour during meiosis in spore mother cells shows the formation of 58 regular bivalents (Figure 1D, E), which regularly separate both during first and second telophase (Figure 1F, G) without any abnormality, with the resulting formation of four uniform daughter cells (Figure 1H-I). Mitosis in leaf tip cells, showed double the number ($2n$=116) of chromosomes. Sporangia have 64 regular spores (Figure 1K). Thus, the present gathering from Meghamalai, Western Ghats, India confirms that it is tetraploid and sexual (n=58, $2n$=116); this is the first count from India and a new cytotype for this species.

In Australia, diploid counts of n = 29 and $2n$ = 58 were reported for *P. falcata* from Kaputar National Park, and Sassafras, New South Wales (Tindale & Roy, 2002), and counts of $2n$ = 58 were illustrated from three populations in Queensland and New South Wales by Kokubugata et al. (2007). Several reports of tetraploid sexual plants previously placed under the name *P. falcata* have now been shown to be different species. Thus the report by Brownlie (1961) in material of from Nelson was actually the species *P. calidirupium* (Brownsey & Lovis 1990; Brownsey et al., 2020), and material from Raoul Island, Kermadec Island is better attributed to *P. rotundifolia* (Brownsey et al., 2020).

The gathering of *Pellaea falcata* from Meghamalai, Western Ghats, India is similar in morphology to diploid *P. falcata* from Australia, but the diameter of the echinate spores (Figure 1L) is 39µm in contrast to reports of 27.8-31.8 µm diameter spores from Australian material.

Diploid populations of *P. falcata* are common in Australia but the tetraploid

populations are rare and threatened in India. In India it behaves as a deciduous resurrection plant by completely drying during summer season, shedding all the articulated pinnae and leaving only the rachis, then sprouting abundantly during the winter season. The reason for the rarity of this tetraploid *P. falcata* may be attributed to the low percentage of sporophyte production in *in-vitro* spore culture in composite populations (Srivastava & Khare, 2007). This threatened Asian fern is currently by grown in the Kodaikanal Botanical Garden (Figure 1E) and The Government Botanical Garden, Ooty, Tamil Nadu (Kumar et al., 2012). The local forest officials at Meghamalai have also been requested to help conserve the existing populations in situ.

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SHORT NOTE

ASPLENIUM LEPTURUS FORMA *FILIFORME* (ASPLENIACEAE), A NEW FORM FROM SOUTH-EAST ASIA.

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Asplenium lepturus forma ***filiformе*** Salgado, **forma nov.**
Based on *Asplenium lepturus* C.Presl, Epim. Bot. 1849. 72, 73 *pro parte*. Type: Philippine, Luzon, *Cuming 211*, holotype B200017192; isotypes K000451012, P00642967, US135099; paratypes K000451001, US01516499, P01553014, P01485368, L3510538.
Range: Philippines, Laos, Vietnam.
Rhizome creeping, covered with dark reddish-brown scales. Fronds seriate, up to 100 cm long. Pinnae falcate, 6.0-15 cm long, 0.5-1.0 cm wide, apex long caudate to filiform, acroscopic base narrow cuneate, acroscopic basal lobe absent, basiscopic base excised, margin serrate proximally, with distal prominent angular teeth. This form of *A. lepturus* has never been described but the name has been used occasionally in the identification of herbarium specimens. It differs from the nominate form *lepturus* in the dimensions and shape of the pinnae; the forma *filiformе* is 0.5-1.0 cm wide in the middle section of the pinna, while the forma *lepturus* is usually <1.5 cm in the middle section, the acroscopic pinna base is narrow cuneate and lacks the acroscopic lobe, pinna margins are proximally serrate or with prominent teeth placed at an angle in the distal portion of the pinna; the pinna apex is very long caudate and thin. There are, however, intermediate forms that gradually and imperceptibly merge the two forms, *filiformе* and *lepturus*. The collections labeled *Cuming 211* are a mixture of two.
Ecology: Mostly epiphytic or epilithic, rarely terrestrial; inhabiting cloud forests above 1200 m elevation, in association with mosses and lichens.

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Figure 1. *Asplenium lepturus* forma *filiforme*, isotype *Cuming 211*, US00135099.

Figure 2. *Asplenium lepturus* forma *lepturus*, isotype *Cuming 211*, K000451010.

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